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CONNECTICUT RIVER BASIN

MASTER MANUAL
OF
RESERVOIR REGULATION

APPENDIX E

ASHUELOT RIVER WATERSHED
SURRY MOUNTAIN LAKE
OTTER BROOK LAKE

NEW HAMPSHIRE AND MASSACHUSETTS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

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CONNECTICUT RIVER FLOOD CONTROL
MASTER MANUAL
OF
RESERVOIR REGULATION
SURRY MOUNTAIN LAKE
AND
OTTER BROOK LAKE

APPENDIX E
ASHUELOT RIVER WATERSHED
NEW HAMPSHIRE AND MASSACHUSETTS

Department of the Army
New England Division, Corps of Engineers
Waltham, Massachusetts

February 1962
Revised January 1972

CONNECTICUT RIVER FLOOD CONTROL

MASTER MANUAL
OF
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Appendix	Watershed	Reservoirs	Status
Master Manual	Connecticut River	-	Started
A	Ompompanoosuc River	Union Village	Completed 1950 (Revised 1971)
B	Ottauquechee River	North Hartland	Completed 1969
C	Black River	North Springfield	Completed 1968
D	West River	Ball Mountain Townshend	Completed 1965 (Being revised)
E	Ashuelot River	Surry Mountain Otter Brook	Completed 1962 (Revised 1972)
F	Millers River	Birch Hill Tully	Completed 1950 (Being revised)
G	Chicopee River	Barre Falls Conant Brook	Completed 1964
H	Westfield River	Knightville Littleville	Completed 1967
J	Farmington River	Colebrook River Mad River Sucker Brook	Completed 1970

P R E F A C E

The Ashuelot River watershed is located in southwestern New Hampshire with a small portion in north-central Massachusetts. It has a drainage area of 421 square miles. The flood control plan for the watershed described in this manual includes two dams and reservoirs. Surry Mountain Lake is located in the town of Surry, New Hampshire, and Otter Brook Lake in the city of Keene, New Hampshire.

This Appendix of the Connecticut River Master Regulation Manual includes a description of the basin; statistical, climatological and flood data; project descriptions and regulation procedures for both flood control projects. In addition to setting forth a method of reservoir regulation, the manual will serve as a reference source for future studies.

The manual is broken down into seven chapters: Introduction, Hydrology, Communications, Hydrologic Forecasts, Reservoir Regulation, Management and Hydrologic Equipment. The setup of chapters allows the reader to obtain desired general background information on any particular aspect of the projects.

Pertinent data on the hydrologic information of the watershed, Surry Mountain and Otter Brook Lakes are shown on pages i, ii and iii at the front of the manual.

The chapter on Reservoir Regulation contains detailed procedures and information necessary for regulating the protective works to provide protection for the city of Keene and other downstream communities on the Ashuelot and Connecticut Rivers.

MANUAL OF RESERVOIR REGULATION

ASHUELOT RIVER WATERSHED

NEW HAMPSHIRE AND MASSACHUSETTS

APPENDIX "E"

CHAPTER II

HYDROLOGY

CHAPTER III
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CHAPTER IV
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CHAPTER VI
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PERTINENT DATA
ASHUELOT RIVER WATERSHED
HYDROLOGIC INFORMATION

DRAINAGE AREA	Square Miles
Ashuelot River at Gilsum (USGS Gage)	71.1
Ashuelot River at Surry Mountain Lake	100
Ashuelot River below Surry Mountain Lake (USGS Gage)	101
Ashuelot River at The Branch	114
The Branch at Ashuelot River	100
Otter Brook at Otter Brook Lake (USGS Gage)	47.2
Otter Brook at The Branch	55
Minnewawa Brook at The Branch	33
Beaver Brook at Beaver Brook Lake Site	6
Beaver Brook at The Branch	10
Ash Swamp Brook at Mouth	18
South Branch Ashuelot River at Webb (USGS Gage)	36
South Branch Ashuelot River at Honey Hill Lake Site	70
South Branch Ashuelot River at Mouth	72
Local Keene to West Swanzey	8
Ashuelot River at West Swanzey Dam	312
Mirey Brook at Mouth	29
Ashuelot River at Hinsdale (USGS Gage)	420
Ashuelot River at Mouth	421

TEMPERATURE AT KEENE	Degrees F.
Maximum Recorded	104 (July)
Mean Annual	45.8
Minimum Recorded	-32 (Jan & Feb)

PRECIPITATION AT KEENE	Inches
Maximum Annual	51.20 (1951)
Mean Annual	38.53
Minimum Annual	27.12 (1894)

WATER EQUIVALENT IN SNOW COVER (Entire Waterhsed)

	Dec 1948-Apr 1971		
	Maximum (inches)	Mean (inches)	Minimum (inches)
1 February	5.5	3.0	0.9
15 February	7.6	3.4	0.0
1 March	9.6	4.6	0.7
15 March	9.4	5.2	1.0
1 April	8.8	3.9	0.0
15 April	6.5	1.2	0.0

USGS GAGES	Period of Record
Ashuelot River at Gilsum, N.H.	Aug 1922 - To Date
Ashuelot River below Surry Mt. Lake, near Keene, N.H.	Sep 1945 - To Date
Otter Brook below Lake, near Keene, N.H.	May 1958 - To Date
*Otter Brook near Keene, N.H.	Oct 1923 - May 1958
South Branch Ashuelot River at Webb, N.H.	Oct 1920 - To Date
Ashuelot River at Hinsdale, N.H.	Mar 1907 - To Date

* Gaging station relocated downstream of Otter Brook Lake in May 1958.

FLOW RECORDS

	Ashuelot River at Surry Mt. Lake		Otter Brook near Keene, N.H.	
	Date	Flow cfs	Date	Flow cfs
Minimum Average Daily	9/17/64	0.4	9/ 2/57	1.1
Minimum Average Monthly	11/65	4.0	8/56	2.2
Minimum Average Annual	1957	97.5	1930	39.4
Maximum Average Daily	-	-	9/21/38	4,040
Maximum Average Monthly	4/60	1,022	3/36	440
Maximum Average Annual	1960	232	1938	110
Maximum Instantaneous	4/ 5/60	4,550	9/21/38	6,130
Average Annual		166		71

PEAK FLOWS

Ashuelot River nr. Gilsum, N.H.		Otter Brook nr. Keene, N.H.		Ashuelot River at Hinsdale, N.H.	
Date	Peak Flow cfs	Date	Peak Flow cfs	Date	Peak Flow cfs
Sep 21, 1938	5,220	Sep 21, 1938	6,130	Mar 19, 1936	16,600
Mar 18, 1936	4,400	*Oct 24-25, 1959	5,000	Sep 22, 1938	16,200
Nov 26, 1950	3,700	Mar 18, 1936	3,580	Nov 4, 1927	13,400
Apr 12, 1934	3,490	Nov 26, 1950	3,540	Mar 29, 1920	9,550
Apr 5, 1960	2,800	Nov 4, 1927	3,180	Apr 7, 1923	8,940
Nov 4, 1927	2,760	Apr 12, 1934	3,020	Apr 5, 1960	8,800
Oct 24, 1959	2,700	*Apr 5, 1960	2,000	Apr 14, 1940	8,650

* Estimated flow at gaging station.

ANNUAL RUNOFF

	Hinsdale, N.H.			Gilsum, N.H.		
	Inches	CFS	Water Year	Inches	CFS	Water Year
Maximum	35.49	1,093	1960	36.60	191	1960
Mean	20.88	628	(59 Years)	23.30	122	(47 Years)
Minimum	7.04	216	1965	7.60	40	1965

FLOOD ROUTING COEFFICIENTS

	3-Hour Increments	
Reach	Routing Coefficient	River Miles Between Points
Surry Mt. to Keene Telemark	5/2	6.2
Otter Brook to Keene Telemark	3/1	4.9
Keene to West Swanzey Dam	11/4	8.7
West Swanzey to Mouth	5/3	19
Mouth of Ashuelot to Montague City, Mass.	3/1*	21

* 6-Hour Increments

HIGH FLOW TRAVEL TIMES

	Total Hours from Dam	
	Surry Mountain	Otter Brook
Island Street	4 - 5	-
Keene Telemark	4 - 6	3 - 4
West Swanzey Dam	16 - 18	14 - 16
Winchester, N.H. Gage	21 - 25	19 - 23
Montague City, Mass.	31 - 35	29 - 33

PERTINENT DATA
SURRY MOUNTAIN LAKE

LOCATION Ashuelot River, Surry, New Hampshire

DRAINAGE AREA 100 square miles

STORAGE USES
- Flood Control
- Recreation

RESERVOIR STORAGE

	Elevation msl	Stage feet	Area acres	Capacity Acre-Feet	Capacity Inches on Drainage Area
Inlet Elevation	485.0	0	0	0	0
Recreation Pool	500	15	260	1,320	0.25
Spillway Crest	550.0	65.0	970	31,680 (net)	5.9 (net)
Maximum Surcharge	562.4	77.4	1,195	13,400 (net)	2.5 (net)
Top of Dam	568.0	83.0			

EMBANKMENT FEATURES

Type	Rolled earth fill, rock slope protection, impervious core
Length (ft)	1,800
Top Width (ft)	30
Top Elevation (ft,msl)	568.0
Height (ft)	86
Volume (cy)	1,105,000
Dike	None

SPILLWAY

Location	Right-West Abutment
Type	Uncontrolled, ogee weir L-shaped side channel spillway
Crest Length (ft)	338
Crest Elevation (ft,msl)	550.0
Surcharge (ft)	12.4
Design Head (ft)	13.0
Maximum Discharge Capacity (cfs)	50,000

OUTLET WORKS

Type	Boston Horseshoe
Tunnel Inside Diameter (ft)	10
Tunnel Length (ft)	383
Service Gate Type	Broome
Service Gate Size	Two, 4'6" x 10'
Emergency Gate Type	Broome
Emergency Gate Size	Two, 4'6" x 10'
Downstream Channel Capacity	
Growing Season (cfs)	800
Non-Growing Season (cfs)	1,200
Maximum Discharge Capacity	
Spillway Crest Elevation (cfs)	3,700
Stilling Basin	None

RECREATION WEIR

Type	Concrete
Location	Upstream of both gates
Weir Length (ft)	25 (approx.)
Stop Logs	None
Crest Stage (ft)	14.5
Recreation Pool Stage (ft)	15 (approx.)
Manually Operated Gate	2' x 3'

RECREATION POOL

Length (ft)	5,900
Shoreline Length (ft)	20,100
Area (acres)	260

LAND ACQUISITION

Fee Elevation (ft, msl)	550
Fee (acres)	1,688
Easement (acres)	18
Clearing Elevation (ft. msl)	502±

MAXIMUM POOL OF RECORD

Date	March 29, 1948
Stage (ft)	57.6
Percent Full	79

SPILLWAY DESIGN FLOOD

	Original Design 1939	1961 Analysis
Peak Inflow (cfs)	44,800	63,000
Peak Outflow (cfs)	40,900	54,000*
Volume Runoff (acre-ft)	76,200	104,500

* 50,000 Spillway Discharge; 4,000 Conduit Discharge (See Plate E-26)

UNIT RUNOFF

One Inch Runoff (acre-ft)	5,330

OPERATING TIME

Open/Close all Gates	5 min. (Manual Operation: Gravity closure, 90 turns/ft. rise)

PROJECT COST (thru FY71) $2,720,000

DATE OF COMPLETION October 1941

MAINTAINED BY New England Division, Corps of Engineers

PERTINENT DATA
OTTER BROOK LAKE

LOCATION	Otter Brook, Keene, New Hampshire
DRAINAGE AREA	47.2 square miles

STORAGE USES
- Flood Control
- Recreation

RESERVOIR STORAGE

	Elevation msl	Stage feet	Area acres	Acre-Feet	Inches on Drainage Area
Inlet Elevation	683.0	0	12	0	0
Recreation Pool	701	18	70	720	0.3
Spillway Crest	781.0	98.0	374	17,600 (net)	7.0 (net)
Maximum Surcharge	798.3	115.3	452	7,100 (net)	2.9 (net)
Top of Dam	802.0	119.0			

EMBANKMENT FEATURES

Type	Rolled earth fill, rock slope protection, impervious core
Length (ft)	1,288
Top Width (ft)	25
Top Elevation (ft,msl)	802.0
Height (ft)	133
Volume (cy)	973,000
Dike	None

SPILLWAY

Location	Right-West Abutment
Type	Uncontrolled, ogee weir, chute spillway
Crest Length (ft)	145
Crest Elevation (ft,msl)	781.0
Surcharge (ft) (1967 criteria)	17.3
Design Head (ft)	13.0
Maximum Discharge Capacity (cfs)	40,000

OUTLET WORKS

Type	Boston Horseshoe
Tunnel, Inside Diameter (ft)	6
Tunnel Length (ft)	589
Service Gate Type	Hydraulic Slide
Service Gate Size	Three 2'6" x 4'6"
Emergency Gate	None
Downstream Channel Capacity (cfs)	600
Maximum Discharge Capacity Spillway Crest (cfs)	1,320
Stilling Basin	35 ft. long, 25 ft. wide with baffles and 4ft. end sill

RECREATION WEIR

Type of Structure	Concrete weir w/5 stoplog openings
Location	Upstream of center gate
Weir Length (ft)	31'8"
Stoplog Openings	6' deep by 6'4" wide
Stoplog Sill Stage (ft)	15
Recreation Pool Stage (ft)	18
Manually Operated Gate	6" Diameter Opening

RECREATION POOL

Length (ft)	5,300
Shoreline Length (ft)	12,600
Area (acres)	70

LAND ACQUISITION

Fee Elevation (ft, msl)	755
Fee (acres)	461
Easement Elevation (ft. msl)	797
Easement (acres)	152
Clearing Elevation (ft. msl)	703±

MAXIMUM POOL OF RECORD

Date	April 25, 1969
Stage (ft)	82.6
Percent Full	71

SPILLWAY DESIGN FLOOD

	Original Design 1955	1967 Analysis
Peak Inflow (cfs)	38,000	45,000
Peak Outflow (cfs)	34,500	41,500*
Volume Runoff (acre-ft)	53,000	44,800

* 40,000 Spillway Discharge; 1,500 Conduit Discharge (See Plate E-27)

UNIT RUNOFF	
One Inch Runoff (acre-ft)	2,510
OPERATING TIME	
Open/Close all Gates	10 min. (No Manual Operation of Gates)
PROJECT COST (thru FY71)	$4,061,000
DATE OF COMPLETION	April 1958
MAINTAINED BY	New England Division, Corps of Engineers Recreation facilities operated and maintained by N.H.

MANUAL OF RESERVOIR REGULATION
ASHUELOT RIVER WATERSHED
NEW HAMPSHIRE AND MASSACHUSETTS

CHAPTER I

INTRODUCTION

1. REGULATION MANUAL

a. Authorization. This report is prepared pursuant to authority contained in ER 1110-2-240, dated 25 March 1963 (Reservoir Regulation) and EM 1110-2-3600, dated 25 May 1959 which requires that manuals of reservoir regulation for flood control, navigation or multiple-purpose reservoirs be prepared whenever storage allocated to one or more of the functions is the responsibility of the Corps of Engineers.

b. Purpose and Scope. This manual will serve as a guide and reference source for higher authority, reservoir regulation and maintenance personnel in the New England Division Office, respective flood control dam operators, and other personnel who may become concerned with or responsible for regulation of the reservoirs in the Ashuelot River watershed. Included in the manual are the following chapters:

(1) Introduction. A brief history of flood problems and studies which led to the authorization of the Ashuelot River watershed flood control projects, including statistical data relative to population, industry and agriculture.

(2) Hydrology. A general description of the watershed and major tributaries, including topographic features and a general coverage of the hydrologic and meteorologic data such as temperature, precipitation, snowfall, snow cover, storms, streamflow and floods.

(3) Communications. A brief description of the means of reporting from field to office such as used by the dam operators during the normal and flood periods, and of the river reporting network and Automatic Hydrologic Radio Reporting System.

(4) Hydrologic Forecasts. A description of all forecasts used in regulating the projects in the basin, such as precipitation forecasts from the National Weather Service, river predictions from the River Forecast Center at Hartford and from the Corps of Engineers.

(5) Reservoir Regulation. A detailed discussion of the regulation procedures and watershed flood control plan for the two existing flood control lakes.

(6) Management. A general description of the functional responsibilities of the Corps in regard to regulation of the projects, with a listing of all interagency coordinating agreements.

(7) Operational Procedures and Maintenance of Hydrologic Equipment. A brief resume of hydrologic equipment used and means of maintaining it.

2. PROJECT DESCRIPTIONS

a. Location. The Ashuelot River, a map of which is shown on plate E-3, is a tributary of the Connecticut River and is located in the southwest corner of New Hampshire with a small portion extending into the north-central part of Massachusetts. Plates E-1 and E-2 show the Upper and Lower Connecticut River basin, respectively.

(1) Surry Mountain Lake. This project is located in the town of Surry, New Hampshire, on the Ashuelot River about 5 miles northwest of Keene, New Hampshire and about 34.6 miles above the confluence of the Ashuelot and Connecticut Rivers.

(2) Otter Brook Lake. This project is located in the city of Keene, New Hampshire, on Otter Brook, a tributary of the Branch, which in turn is a tributary of the Ashuelot River. The dam is 2.7 miles above the confluence of Otter and Minnewawa Brooks.

b. Purpose. Both lakes are flood control projects. Their purposes are primarily to provide flood protection for the community of Keene, and secondly to reduce flood stages at other downstream communities on the Ashuelot and Connecticut Rivers. In addition, they provide water-based recreational facilities.

c. Physical Components.

(1) Surry Mountain Lake. The important physical components consist of a rolled earth dam with rock slope protection, side channel spillway outlet works, storage for flood control and facilities for recreational purposes.

The dam embankment, shown on plate E-8, consists of compacted earth and rock slope protection, and is approximately 1,800 feet long with a maximum height above the streambed of 86 feet. The top of dam at elevation 568 feet, msl provides 12.4 feet of spillway surcharge and 5.6 feet of freeboard. The top width of 30 feet accommodates a 15-foot paved access road. The embankment slopes vary from 1 on 2.5 to 1 on 5.

The spillway, located in a rock cut at the west abutment, consists of a 338-foot L-shaped side channel spillway ogee weir with crest at elevation 550.0, which is 10 feet above the approach channel. The discharge channel is approximately 30 feet wide and its bottom slopes vary from approximately 12 to less than one percent. The flows are returned through the 2,000 foot length of the channel to the Ashuelot River. Plan, profile and cross sections of the spillway are shown on plate E-9.

The outlet works, shown on plate E-10, consist of an approach channel, intake structure, discharge conduit and discharge channel. A 10-foot diameter Boston Horseshoe conduit, 383 feet in length, passes through the foundation to the discharge channel which empties into the Ashuelot River at the downstream toe. The gate structure contains two 4'6" x 10' chain operated broome gates for regulation purposes and two similar sized emergency gates in series with the regulating gates. The inlet invert elevation is 485.0 feet, msl. The permanent pool is controlled by a weir with a crest elevation of 495.5 feet, msl located immediately upstream of both flood control gates. (See pertinent data sheet, page ii at front of manual for physical dimensions.)

(2) Otter Brook Lake. The important physical components consist of a rolled earth dam with rock slope protection, chute spillway, outlet works, storage for flood control and facilities for recreational purposes.

The dam embankment, shown on plate E-11, consists of compacted earth and rock slope protection and is 1,288 feet long with a maximum height above the streambed of 133 feet. The top of dam at elevation 802.0 feet, msl provides 17.3 feet of spillway surcharge and 3.7 feet of freeboard (based on review of the design criteria in 1967). The top width of 25 feet accommodates an 18-foot paved access road. The embankment slopes are 1 on 2.5.

The spillway is located in a rock cut at the west abutment. The 145-foot length of the ogee-shaped weir has its crest at elevation 781 feet, msl which is 5 feet above the approach channel. The chute has a width of 142 feet at the spillway apron and transitions uniformly to a width of 60 feet in its 600-foot length. A plan of the spillway is shown on plate E-12.

The outlet works consist of a gate chamber, control tower and operating house on the upstream side of the dam. A 6-foot diameter Boston Horseshoe discharge tunnel passes through the foundation and empties into Otter Brook at the downstream toe of the dam. The plan, profile and sections of the outlet works are shown on plate E-13. The gate structure contains three 2'6" x 4'6" hydraulically operated vertical slide gates used for regulation purposes. The inlet elevation is 683.0 feet, msl. The recreation pool, located immediately upstream of the center flood control gate, is controlled by a weir with crest elevation of 701 feet, msl. (See pertinent data sheet, page iii at front of manual for physical dimensions.)

3. HISTORY OF PROJECTS

a. Authorization.

(1) Surry Mountain Lake. This lake was authorized by the Flood Control Act approved June 22, 1936 (Public Law No. 738, 74th Congress), as amended by Public Law No. 111, 75th Congress, approved May 25, 1937. A permanent conservation-recreation pool was authorized at about a stage of 15 feet by a letter from the Chief of Engineers, dated 19 January 1960.

(2) Otter Brook Lake. This lake was authorized by Flood Control Act, approved 3 September 1954.

b. Construction.

(1) Construction of Surry Mountain Lake was initiated in the summer of 1939. The project was placed in operation in October 1941 with final acceptance in June 1942.

(2) Construction of Otter Brook Lake was initiated in October 1956. The project was placed in operation in April 1958 with final acceptance in September 1958.

c. Related Corps of Engineers Projects.

(1) Ashuelot River Channel Improvement. A clearing and snagging project in 1954 improved the channel of the Ashuelot River below Winchester Street in Keene, allowing increased discharge from Surry Mountain Lake.

(2) Beaver Brook Lake. Beaver Brook, Ashuelot River, Keene, New Hampshire. This project was authorized for multiple-purpose development by the Flood Control Act of 13 August 1968 as reported in Senate Document No. 68, 90th Congress, 2nd Session. Preparation of contract plans and specifications is now under way.

The project, shown on plate E-3, is located in the city of Keene and town of Gilsum, Cheshire County, New Hampshire, 2.5 miles upstream (north) of Keene. The dam, an earth structure, 950 feet long and 60 feet high, controls 6 of the 10 square miles' drainage area of Beaver Brook.

The reservoir, at spillway crest elevation (822.0 msl), impounds 5,750 acre-feet. Of this authorized storage, 3,000 acre-feet were for water supply and 2,750 acre-feet, equivalent to 8.6 inches of runoff, were for flood control. Provisions for a sedimentation and dead storage pool, or for maintaining minimum downstream releases were not included.

After a detailed hydrologic analysis of current design, sedimentation and dead storage, as well as downstream releases, have been proposed.

A tabulation and brief description of storages is included below.

Purpose	Elevation (ft, msl)	Net Storage Acre-Feet	Net Storage Inches
Sedimentation & Dead Storage Pool	789	110	0.34
Water Supply	789 - 811.5	3,000	9.4
Seasonal Use*	811.5 - 815	730	2.3
Flood Control	815 - 822	1,910	6.0
TOTAL		5,750	19.0

*Flood Control and Minimum Flow

(3) Honey Hill Lake. The project, originally authorized on August 18, 1941, and currently in an inactive status, would be located on the South Branch of the Ashuelot River in the town of Swanzey about 5.6 miles upstream of its confluence with the Ashuelot River. It would consist of an earth embankment of rolled-fill construction. The flood control capacity of the reservoir would be 26,200 acre-feet, equivalent to 7.0 inches of runoff from the drainage of 70 square miles. With the reservoir filled to spillway crest (elevation 524.0 feet, msl), an area of 1,360 acres, including part of East Swanzey, would be inundated. Project purposes originally included flood control and recreation. Appendix M, "Flood Control" of the "Comprehensive Water and Related Land Resources of the Connecticut River Basin," dated June 1970, recommended other beneficial uses, such as low flow augmentation for fish and wildlife enhancement, for improving the water quality of the stream, and possibly industrial water supply on a seasonal usage for the industrial complex located between Winchester and Hinsdale, New Hampshire. The total storage available during this seasonal lowflow period would be 6,700 acre-feet, equivalent to 1.8 inches of runoff. (Refer to plate E-3 for proposed location of Honey Hill.)

d. Other Federal Projects.

(1) Ash Swamp Brook (SCS). The Soil Conservation Service studied and was responsible for the administration of a Watershed Work Plan Agreement on the Ash Swamp and Tannery Brook drainage areas. Ash Swamp Brook, formed by the joining of Black and White Brooks, has a drainage area of 18.8 square miles, while Tannery Brook has a drainage area of 0.8 square miles. The plan provides: (a) for land treatment measures on both the flood plain and surrounding upland areas; (b) structural and channel improvements, such as modifications of bridges, culverts, etc., widening of channels, construction of

branch ditches, etc. As there is no provision for the impoundment of flows in this area, either now or in the future, these improvements have no effect on the regulation procedures of Corps' reservoirs.

e. Modification to Authorization.

(1) Surry Mountain Lake. The original Analysis of Design specified flood control as the only benefit derived from Surry Mountain Lake. Studies initiated in August 1951 determined that a recreation pool would not significantly affect the flood control capability. A recreation weir at stage 14.5, which provides a pool at an approximate stage of 15 feet, was built in 1962.

The maximum allowable discharge from Surry Mountain has been significantly increased since the completion of the project. This increase, from 800 to 1,200 cfs in the nongrowing season and 600 to 800 cfs in the growing season, has been primarily brought about by the improving of the downstream channel in Surry and Keene.

(2) Otter Brook Lake. A study is presently underway to determine the feasibility of utilizing a portion of the storage at Otter Brook Lake on a seasonal basis for water quality releases for downstream communities on the Ashuelot River.

f. Previous Reports. The Ashuelot River watershed has a long history of flooding extending back more than 230 years. During this time, the only reports prepared were survey-type pertaining to the entire Connecticut River basin. Reports which included the Ashuelot River are as follows:

(1) Both Surry Mountain Lake and Otter Brook Lake were among the projects included in the flood control compact by the States of Connecticut, Massachusetts, New Hampshire and Vermont, and approved on 6 June 1953, Public Law 52, 83rd Congress.

(2) Flood Control of the Ashuelot River was also considered in Part Two, Chapter XXI of "The Resources of the New England-New York Region," dated March 1955 and printed in Senate Document 14, 85th Congress. It consisted of a comprehensive survey of land, water and related natural resources of the region. The report, prepared by the New England-New York Interagency Committee, was submitted to the President of the United States by the Secretary of the Army on 27 April 1956.

(3) "The Connecticut River Basin Comprehensive Report," dated June 1970, also mentions both projects along with the proposed Honey Hill project and Beaver Brook, which is under design. Surry Mountain and Otter Brook are mentioned in regard to the entire comprehensive plan of flood control throughout the basin.

g. Principal Project Problems at Surry Mountain Lake. In late August 1941 a series of small rock slides occurred near Station 2+00 on the west slope of the spillway channel excavation. The total quantity involved in these slides was approximately 475 cubic yards.

On 10 March 1942, another slide, involving between 500 and 800 cubic yards, occurred. Still another slide, involving an estimated 5,500 cubic yards, occurred on 28 March 1943. During the period from August 1943 to January 1944, this slide material together with a large volume of rock on the adjacent hillside, which was on the point of falling, was removed. Total volume of rock removed was about 32,000 cubic yards. This work included the construction of a bulkhead to protect the access bridge abutment.

Between 1944 and 1961, several blocks fell into the channel downstream of the previous slide area, but they were not of such quantity as to require removal. About half of these blocks fell during the winter and spring of 1960-61. Removal of the rock above a schistose zone, intersecting the west side of the spillway channel, was accomplished in 1961. The rock removal flattened the slope to approximately 1 on 1, leaving the slope in a stable condition. The plan provided for removing the rock and west abutment supporting the access bridge and replacing it with a new two-span girder bridge with central pier located at the site of the old abutment. The construction of the new bridge was completed in 1962.

h. Principal Project Problems at Otter Brook Lake. There have been no major problems at Otter Brook Lake.

i. Current Studies. The New England Division, Corps of Engineers, is performing a flood plain information study requested by the city of Keene, New Hampshire. The limits of this study run along the Ashuelot River from the outlet works at Surry Mountain Lake to the southern city limits. The study is scheduled for completion in the spring of 1972.

4. ECONOMY OF THE WATERSHED

a. General. The economy of the Ashuelot River watershed area can be characterized as stable and highly industrialized. The city of Keene, with a population in excess of 20,000 persons, almost one-half the population of the watershed area according to the 1970 census, is the fifth largest municipality in the State of New Hampshire and the economic center of the watershed. Over forty manufacturers in the city produce precision ball bearings, machine tools, furniture, shoes, textiles, optical goods, business forms, toys, jewelry findings, machinery and other manufactured products.

b. Population. Historical population data for the Ashuelot River watershed area and the State of New Hampshire are shown in the following tabulation.

	1940	1950	1960	1970
Ashuelot	28,500	31,900	35,400	41,750
New Hampshire	491,520	533,240	606,920	722,750

Population in the Ashuelot River watershed has increased by 46.5 percent between 1940 and 1970, rising from a level of 28,500 to 41,750 persons. For comparison purposes, New Hampshire population increased by 47.0 percent during the 30-year period.

c. Agriculture. Outside the central city of Keene, the watershed area is sparsely populated and more noticeably rural in nature. Because of fairly heavy forests and hilly terrain, this region has not shared in the extensive recreational development in New Hampshire nor has agricultural productivity been exceptionally large. As is the case in the rest of New England, the area has experienced a decline in both the number of operating farms and the acreage under cultivation. Most of the agricultural activity in the area is devoted to dairy farming and the production of apples.

CHAPTER II

HYDROLOGY

5. DESCRIPTION OF WATERSHED

The Ashuelot River watershed is located in the southwest corner of New Hampshire in Sullivan and Cheshire Counties, with a small section in north-central Massachusetts in Franklin County. The watershed, diamond-shaped, has a length of 42 miles and a width of 17 miles. The drainage area at the confluence of the Ashuelot and Connecticut Rivers is 421 square miles, of which 100 are controlled by Surry Mountain Lake and 47 by Otter Brook Lake. The river has a total fall of 1,475 feet in its 64 mile length, most of which is concentrated near its headwaters. Generally, the watershed is hilly with low mountains in the headwaters and a few natural ponds and lakes scattered throughout the area. Photographs of Ashuelot Pond and Granite Lake are shown on plates E-53 and E-54, respectively.

The terrain in the upper watershed is steep and conducive to rapid runoff above the Keene flood plain. The elevation of the watershed varies from 3,165 feet, msl at Monadnock Mountain in the southeastern headwaters to 227 feet, msl at the mouth in the southwestern portion. A profile of the river is shown on plate E-4.

The two main tributaries of the Ashuelot River are the Branch and the South Branch Ashuelot River. The Branch enters the Ashuelot just below Keene, New Hampshire, about 26.5 miles upstream from the mouth of the Ashuelot River and is formed by the confluence of Otter Brook and Minnewawa Brook. The South Branch Ashuelot joins the Ashuelot just above Swanzey Station, about 23.5 miles upstream from the mouth.

Discharges from the main river, the Branch and the South Branch Ashuelot River converge in a flood plain just below Keene (plate E-5). The flood plain extends from the Faulkner and Colony dam in Keene downstream to the Homestead Woolen Company dam in West Swanzey. The upper end of this large flood plain is the critical damage area in Keene. Photographs of these two dams plus the Village Pond dam at Marlow, New Hampshire, are shown on plate E-52.

6. CLIMATE AND RUNOFF

a. Precipitation. The mean annual precipitation over the Ashuelot River watershed is approximately 40 inches, distributed uniformly throughout the year. The monthly records at Keene vary from a maximum

TABLE E-1

MONTHLY PRECIPITATION

(Depth in Inches)

	Surry Mountain Lake, N.H. Elev. 540 ft, msl 22 Years of Record Through 1970			Vernon, Vt. Elev. 225 ft, msl 73 Years of Record Through 1970			Otter Brook Lake, N.H. Elev. 680 ft, msl 13 Years of Record Through 1970			Bellows Falls, Vt. Elev. 300 ft, msl 69 Years of Record Through 1970		
Month	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum
January	2.71	5.54	0.71	3.19	5.73	0.89	2.27	4.67	0.66	2.80	6.22	0.62
February	2.49	4.97	0.90	2.91	4.75	1.05	2.77	4.93	1.04	2.65	4.80	0.70
March	2.74	6.13	1.21	3.37	8.35	1.54	2.74	4.11	1.46	3.02	6.82	1.05
April	3.02	4.61	1.10	3.52	6.14	1.12	3.04	4.73	1.08	3.31	5.16	1.37
May	3.07	6.06	1.10	3.44	5.84	0.49	3.29	6.54	1.28	3.26	6.53	0.80
June	3.22	5.82	1.24	3.55	8.72	1.55	3.54	7.98	1.18	3.40	5.71	0.83
July	2.80	6.29	0.54	3.81	5.81	0.71	3.22	7.06	0.81	3.43	5.26	0.67
August	3.26	7.50	1.13	3.85	8.99	0.83	3.60	5.62	1.44	3.31	6.39	1.13
September	3.21	7.54	0.39	3.82	7.62	0.48	3.14	6.23	0.31	3.36	7.18	0.36
October	2.67	7.21	0.68	3.04	8.63	1.07	2.85	7.50	0.93	2.77	6.60	0.51
November	3.74	6.01	1.64	3.87	7.38	1.82	3.83	6.59	1.85	3.42	6.86	2.09
December	3.13	5.49	0.92	3.37	7.05	1.03	3.25	5.91	1.11	3.04	6.82	0.59

	Bradford, N.H. Elev. 1,000 ft, msl 32 Years of Record Through 1970			Edward MacDowell Dam, N.H. Elev. 965 ft, msl 21 Years of Record Through 1970			Keene, N.H. Elev. 490 ft, msl 79 Years of Record Through 1970		
Month	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum
January	3.19	8.04	0.58	3.72	7.66	0.63	2.86	6.50	0.76
February	3.13	6.86	0.93	3.65	6.32	0.99	2.66	7.02	0.60
March	3.36	8.91	1.36	4.16	6.95	2.17	3.13	7.60	0.40
April	3.51	5.90	1.18	3.75	6.18	0.93	3.14	6.65	0.35
May	3.64	8.76	0.60	3.50	7.22	0.88	3.31	7.02	0.79
June	3.71	6.06	1.20	3.28	7.26	0.85	3.40	7.73	0.41
July	3.20	5.67	0.89	3.28	6.95	0.63	3.72	11.09	1.07
August	3.37	8.31	1.68	3.76	6.72	0.81	3.59	8.96	1.05
September	3.42	9.41	0.57	3.88	9.98	0.70	3.52	10.39	0.20
October	3.07	8.12	0.95	3.59	10.06	0.60	2.74	7.84	0.23
November	4.58	7.60	2.73	5.04	9.58	2.35	3.36	7.67	0.52
December	3.96	8.85	1.11	4.35	7.55	0.95	3.10	6.70	0.51

TABLE E-2

ANNUAL PRECIPITATION

(Depth in Inches)

WATER YEAR	KEENE, N.H. ELEV. 490 FT, MSL 79 YEARS OF RECORD THROUGH 1970	VERNON, VT. ELEV. 225 FT, MSL 73 YEARS OF RECORD THROUGH 1970	BELLOWS FALLS, VT. ELEV. 300 FT, MSL 69 YEARS OF RECORD THROUGH 1970	BRADFORD, N.H. ELEV. 1,000 FT, MSL 32 YEARS OR RECORD THROUGH 1970	SURRY MT. LAKE, N.H. ELEV. 540 FT, MSL 22 YEARS OF RECORD THROUGH 1970	EDWARD MAC DOWELL DAM, N.H. ELEV. 965 FT, MSL 21 YEARS OF RECORD THROUGH 1970	OTTER BROOK LAKE, N.H. ELEV. 680 FT, MSL 13 YEARS OF RECORD THROUGH 1970
1886	----	40.76	----	----	----	----	----
1887	----	51.35	----	----	----	----	----
1888	----	60.52*	----	----	----	----	----
1889	----	52.59	----	----	----	----	----
1890	----	49.36	----	----	----	----	----
1891	----	39.14	----	----	----	----	----
1892	35.42	39.49	----	----	----	----	----
1893	42.14	47.05	----	----	----	----	----
1894	27.12**	31.36	----	----	----	----	----
1895	37.85	37.85	----	----	----	----	----
1896	32.75	34.36	----	----	----	----	----
1897	49.53	56.98	----	----	----	----	----
1898	44.00	50.45	----	----	----	----	----
1899	33.85	40.66	----	----	----	----	----
1900	44.68	50.38	----	----	----	----	----
1901	46.28	50.10	----	----	----	----	----
1902	43.24	----	----	----	----	----	----
1903	34.99	----	34.34	----	----	----	----
1904	34.55	----	27.52	----	----	----	----
1905	33.26	----	29.60	----	----	----	----
1906	35.05	----	----	----	----	----	----
1907	40.90	----	----	----	----	----	----
1908	30.59	----	----	----	----	----	----
1909	33.92	----	----	----	----	----	----
1910	30.13	----	----	----	----	----	----
1911	34.42	----	36.47	----	----	----	----
1912	38.24	----	44.31	----	----	----	----
1913	31.30	----	31.42	----	----	----	----
1914	29.47	26.62**	27.45**	----	----	----	----
1915	43.81	39.69	41.50	----	----	----	----
1916	41.80	37.23	34.96	----	----	----	----
1917	36.95	29.59	29.74	----	----	----	----
1918	37.90	32.98	36.04	----	----	----	----
1919	37.69	35.19	37.00	----	----	----	----
1920	48.30	39.60	41.01	----	----	----	----
1921	39.51	37.94	35.76	----	----	----	----
1922	42.76	40.74	38.98	----	----	----	----
1923	40.97	44.03	41.08	----	----	----	----
1924	32.59	34.15	32.92	----	----	----	----
1925	36.75	39.57	39.49	----	----	----	----
1926	38.82	38.05	31.01	----	----	----	----
1927	39.79	41.90	37.48	----	----	----	----
1928	38.96	44.79	33.70	----	----	----	----
1929	36.29	38.49	38.63	----	----	----	----
1930	30.23	34.18	31.84	----	----	----	----
1931	39.34	40.26	41.70	----	----	----	----
1932	34.93	41.03	34.39	----	----	----	----
1933	42.23	44.56	41.02	----	----	----	----
1934	38.71	44.56	42.13	----	----	----	----
1935	36.95	39.96	35.97	----	----	----	----
1936	45.61	47.83	44.36	----	----	----	----
1937	46.61	51.87	45.55	----	----	----	----
1938	48.49	50.57	46.02	----	----	----	----
1939	35.04	41.76	39.78	37.14	----	----	----
1940	39.19	40.48	43.99	42.97	----	----	----
1941	30.89	31.51	28.62	30.43	----	----	----
1942	40.62	45.93	40.66	45.41	----	----	----
1943	33.63	41.37	37.79	41.20	----	----	----
1944	36.86	39.00	35.09	45.27	----	----	----
1945	47.90	52.46	48.72	55.50*	----	----	----
1946	35.88	38.53	37.42	43.13	----	----	----
1947	39.92	41.31	41.35	42.78	----	----	----
1948	39.31	38.34	38.21	----	----	----	----
1949	36.49	----	37.72	33.31	33.49	----	----
1950	41.76	44.83	43.45	42.79	39.27	----	----
1951	51.20*	53.32	53.53*	55.22	46.94*	52.73	----
1952	34.99	42.83	41.62	44.15	35.33	42.64	----
1953	49.89	46.77	43.79	51.35	43.14	54.19	----
1954	47.48	44.18	42.97	52.05	43.39	54.93	----
1955	40.12	44.54	37.79	43.56	37.10	45.31	----
1956	41.74	38.63	38.82	41.35	34.34	45.24	----
1957	34.27	32.32	30.60	36.88	32.04	37.93	----
1958	36.77	37.83	33.54	43.11	33.18	48.90	----
1959	46.94	50.07	46.65	43.95	43.15	53.87	45.70
1960	47.08	50.67	47.00	47.65	43.69	56.16*	45.10
1961	33.95	36.68	34.37	36.18	31.26	43.06	32.32
1962	40.15	37.99	40.26	43.34	40.53	49.32	39.84
1963	31.20	33.16	32.71	35.03	30.31	37.69	27.56**
1964	29.37	34.26	31.65	35.54	26.97**	37.50	28.46
1965	30.54	33.18	28.62	29.36**	29.21	34.31**	30.96
1966	31.07	32.76	36.49	39.51	32.07	38.46	31.48
1967	42.78	39.81	37.42	39.49	36.75	47.50	41.79
1968	39.26	45.97	43.64	49.54	35.37	48.35	41.08
1969	45.58	50.49	44.56	55.49	39.06	48.58	50.68*
1970	37.54	40.79	35.97	38.47	33.64	42.76	39.30
MEAN ANNUAL	38.53	41.75	37.77	42.55	36.26	45.94	37.86

* MAXIMUM ANNUAL PRECIPITATION FOR PERIOD OF RECORD

** MINIMUM ANNUAL PRECIPITATION FOR PERIOD OF RECORD of 11.09 inches in July to a minimum of 0.20 inch in September. Monthly precipitation records for the 6 stations in the immediate vicinity plus the precipitation record for Keene are listed in table E-1. The annual precipitation records for the same stations are listed in table E-2.

b. Temperature. The average annual temperature at Keene is about 46° Fahrenheit. Average monthly temperatures vary widely throughout the year from approximately 21° in January to 69° in July. Extremes in temperature range from a low of minus 32° in January and February to a high of 104° in July. Table E-3 lists the mean, maximum and minimum monthly temperatures at Keene.

TABLE E-3

TEMPERATURES* AT KEENE, NEW HAMPSHIRE
(Elevation 500 ft, msl)

78 Years of Record Through 1970

Month	Mean	Maximum	Minimum
January	21.4	66	-32
February	22.5	65	-32
March	32.8	85	-21
April	44.5	91	1
May	55.8	98	21
June	64.5	98	27
July	69.4	104	34
August	67.0	102	27
September	59.9	101	19
October	49.3	90	10
November	37.6	80	-15
December	25.3	64	-29
ANNUAL	45.8	104	-32

* Degrees Fahrenheit

c. Snow and Snow Cover. The mean annual snowfall at Keene is 63.3 inches with 52 percent of this occurring in the months of January and February. The variation of the average monthly snowfall is shown in table E-4. Snow surveys taken in the watershed by the Corps of Engineers since December 1948 and the locations of snow courses are shown on plate E-3 and table E-5. Water content in the snow cover reaches a maximum about the middle of March, and from 1948 to date has averaged about 5.2 inches, with a maximum of 9.4 and a minimum of 1.0 inch (refer to Hydrologic Information Pertinent Data sheet).

TABLE E-4

MONTHLY SNOWFALL

AT KEENE, NEW HAMPSHIRE
(Elevation 500 ft, msl)

72 Years of Record Through 1970

Month	Mean*	Percent of Annual
January	16.3	25.8
February	16.6	26.2
March	11.3	17.9
April	3.2	5.1
May	-	-
June	-	-
July	-	-
August	-	-
September	-	-
October	0.1	0.1
November	3.6	5.6
December	12.2	19.3
ANNUAL	63.3	100.0

*Depth in Inches

TABLE E-5

SNOW COURSE LOCATIONS

Course	Elevation msl	Latitude	Longitude	Period of Record
Alstead	1,400	43° - 08'	72° - 17'	Dec 1948 - To Date
Washington	1,340	43° - 10'	72° - 05'	Dec 1948 - Apr 1961
Sand Pond	1,500	43° - 10'	72° - 11'	Jan 1962 - To Date
Marlow	1,220	42° - 06'	72° - 12'	Dec 1948 - To Date
Surry Mt. Lake	600	43° - 00'	72° - 19'	Dec 1948 - To Date
Granite Lake	1,350	43° - 01'	72° - 09'	Jan 1959 - To Date
Otter Brook Lake	1,050	42° - 57'	72° - 14'	Jan 1959 - To Date

d. Storms. The three general types of storms occurring in the Ashuelot River watershed are continental, coastal and those associated with thunderstorms which may be of local origin or the result of a stationary front. Continental storms originate over the western or central part of the United States and move in a general easterly and northeasterly direction. These storms may be rapidly moving intense cyclones or of the stationary type. They are not limited to any season or month but follow one another at more or less regular intervals with varying intensities throughout the year.

Tropical hurricanes are the most important of the coastal storms. They originate either in the South Atlantic or in the Western Caribbean Sea and generally move in a westerly or northwesterly direction, recurving to the north as they near the mainland, and then to the northeast approaching New England. Although the normal path is to the south and east of New England, they may be deflected over this area by continental cyclonic disturbances or by a large, slow moving, anticyclonic center located northeast of New England. This latter phenomenon is known as a "blocking" high pressure cell. In general, hurricanes are likely to occur during the months of July through October with greater incidence in the months of August and September.

Coastal storms of an extratropical nature differ from the aforementioned hurricanes principally as they originate along the Eastern Seaboard. These storms travel northward along the coast, occurring most frequently during the autumn, winter and spring months. Thunderstorms may be of local origin or the frontal type associated with the summer months.

e. Runoff.

(1) Discharge Records. There are five U.S. Geological Survey gaging stations in the Ashuelot River watershed (locations are shown on plate E-3). The Keene telemark is a nonrecording gage located immediately downstream of the confluence of the Ashuelot River and Branch Brook. The period of record of the stations is shown in the pertinent data sheet of hydrologic information. A daily hydrograph for the period of record from October 1923 to September 1953 at Otter Brook near Keene is shown on plate E-16.

(2) Streamflow Data. The annual runoff for the periods of record through 1969, throughout the watershed, vary from a maximum of 39.89 inches in water year 1928 at South Branch Ashuelot River at Webb near Marlboro, New Hampshire, to a minimum of 6.52 inches in water year 1965. The majority of this runoff is associated with rainfall as opposed to snowmelt. The mean annual runoff represents about 52 percent of the mean annual precipitation. About 54 percent of the runoff occurs in the months of March, April and May. Table E-6 lists the monthly runoff values for the period of record for each of the gaging stations. A tabulation of water year runoff for the gaging stations is shown on table E-7; rating tables are listed on plates E-45 through E-49.

TABLE E-6

MONTHLY RUNOFF

ASHUELOT RIVER
Near Gilsum, N.H.
D.A. = 71.1 Sq. Mi.
1922-1969

Month	Maximum cfs	Maximum Inches	Minimum cfs	Minimum Inches	Average cfs	Average Inches
January	247	4.01	14.3	0.23	102	1.65
February	252	3.70	11.8	0.17	81	1.20
March	803	13.03	29.2	0.47	200	3.24
April	833	13.08	124.0	1.95	422	6.62
May	464	7.52	52.5	0.85	186	3.01
June	251	3.94	9.6	0.15	86	1.34
July	208	3.38	4.4	0.07	39	0.64
August	140	2.27	3.2	0.05	30	0.48
September	448	7.03	2.7	0.04	42	0.66
October	204	3.30	3.7	0.06	50	0.81
November	425	6.66	6.7	0.11	105	1.83
December	307	4.98	15.7	0.25	113	1.83
Water Year	191	36.60	39.8	7.60	122	23.30

ASHUELOT RIVER BELOW SURRY MOUNTAIN LAKE
Near Keene, N.H.
D.A. = 101 Sq. Mi.
1945-1971

Month	Maximum cfs	Maximum Inches	Minimum cfs	Minimum Inches	Average cfs	Average Inches
January	347	3.64	37.6	0.31	142	1.63
February	333	3.05	50.1	0.51	129	1.30
March	473	7.54	88.5	0.90	240	3.22
April	1,022	12.20	167.0	1.85	569	6.33
May	632	5.50	94.5	0.99	288	2.77
June	280	3.13	13.5	0.14	117	1.25
July	87	0.94	5.8	0.07	37	0.41
August	136	1.54	4.9	0.06	32	0.37
September	233	3.11	9.6	0.02	47	0.48
October	239	3.26	4.4	0.07	74	0.88
November	427	4.97	4.0	0.10	146	1.80
December	479	4.37	22.7	0.52	170	1.88
Water Year	279	37.92	57.3	7.96	164.1	22.3

OTTER BROOK
Near Keene, N.H.
D.A. = 42.3 Sq. Mi.
1923-1958

Month	Maximum cfs	Maximum Inches	Minimum cfs	Minimum Inches	Average cfs	Average Inches
January	151	4.10	5.8	0.16	66	1.79
February	134	3.31	13.5	0.33	55	1.37
March	440	12.00	23.2	0.63	127	3.46
April	436	11.51	67.8	1.79	215	5.83
May	220	5.99	32.5	0.88	105	2.85
June	177	4.67	12.5	0.33	54	1.42
July	146	3.98	3.7	0.10	27	0.74
August	84.5	2.30	2.2	0.06	18	0.48
September	341	9.00	1.8	0.05	31	0.82
October	135	3.69	2.9	0.08	27	0.72
November	221	5.83	7.3	0.19	62	1.65
December	154	4.20	10.0	0.27	67	1.83
Water Year	110	35.33	39.4	12.63	70.96	22.79

ASHUELOT RIVER
At Hinsdale, N.H.
D.A. = 420 Sq. Mi.
1907-1969

Month	Maximum cfs	Maximum Inches	Minimum cfs	Minimum Inches	Average cfs	Average Inches
January	1,266	3.55	106.0	0.29	554	1.52
February	1,372	3.41	135.0	0.33	520	1.30
March	4,392	12.11	273.0	0.75	1,178	3.30
April	3,723	10.24	693.0	1.84	1,876	5.00
May	2,175	5.77	341.0	0.91	964	2.56
June	1,390	3.86	96.9	0.25	501	1.34
July	1,182	3.24	60.8	0.17	276	0.75
August	1,032	2.84	50.5	0.14	213	0.59
September	2,394	6.36	58.5	0.11	251	0.66
October	995	2.73	49.2	0.14	278	0.77
November	2,248	5.97	55.4	0.16	542	1.46
December	1,720	4.73	113.0	0.31	600	1.64
Water Year	1,093	35.49	216	7.04	628	20.88

SOUTH BRANCH ASHUELOT RIVER AT WEBB
Near Marlboro, N.H.
D.A. = 36 Sq. Mi.
1921-1969

Month	Maximum cfs	Maximum Inches	Minimum cfs	Minimum Inches	Average cfs	Average Inches
January	120	3.86	6.4	0.20	53	1.68
February	143	4.12	9.3	0.27	45	1.31
March	366	11.73	23.1	0.74	110	3.51
April	356	11.05	64.4	1.99	172	5.34
May	186	5.97	26.6	0.85	78	2.51
June	151	4.69	7.0	0.22	44	1.37
July	102	3.25	3.0	0.09	22	0.71
August	131	4.21	2.7	0.09	17	0.53
September	252	7.81	2.6	0.08	22	0.69
October	133	4.26	2.9	0.09	24	0.76
November	244	7.55	3.7	0.11	52	1.60
December	157	5.03	9.5	0.30	56	1.80
Water Year	105	39.89	17.3	6.52	57.8	21.80

OTTER BROOK BELOW OTTER BROOK LAKE
Near Keene, N.H.
D.A. = 47.2 Sq. Mi.
1958-1969

Month	Maximum cfs	Maximum Inches	Minimum cfs	Minimum Inches	Average cfs	Average Inches
January	97.5	2.42	9.1	0.21	47	1.17
February	73.3	1.67	14.3	0.33	40	0.89
March	157	6.10	29.8	0.71	93	2.51
April	432	11.51	130.0	2.50	266	6.56
May	256	4.80	40.2	0.96	115	2.27
June	141	3.33	3.8	0.08	45	1.03
July	47.9	1.18	2.7	0.06	18	0.44
August	52.7	1.27	2.2	0.05	19	0.45
September	103	2.45	0.8	0.01	20	0.48
October	93.7	3.37	0.9	0.03	35	0.95
November	212	4.85	3.2	0.08	67	1.60
December	187	3.70	12.8	0.36	71	1.68
Water Year	126	36.27	23.2	6.69	59.48	20.10

TABLE E-7

ANNUAL RUNOFF

WATER YEAR	ASHUELOT RIVER AT HINSDALE, N.H. D.A. = 420 SQ. MI. 1907-1969		SOUTH BRANCH ASHUELOT RIVER AT WEBB, NEAR MARLBORO, N.H. D.A. = 360 SQ. MI. 1921-1969		ASHUELOT RIVER NEAR GILSUM, N.H. D.A. - 71.1 SQ. MI. 1922-1969		OTTER BROOK NEAR KEENE, N.H.* D.A. = 42.35 SQ. MI. 1923-1958		ASHUELOT RIVER BELOW SURRY MT. LAKE D.A. = 101 SQ. MI. 1945-1969	
	INCHES	CFS	INCHES	CFS	INCHES	CFS	INCHES	CFS	INCHES	CFS
1907	----	---	----	---	----	---	----	---	----	---
1908	27.81	858	----	---	----	---	----	---	----	---
1909	15.78	488	----	---	----	---	----	---	----	---
1910	15.98	494	----	---	----	---	----	---	----	---
1911	11.22	347	----	---	----	---	----	---	----	---
1912	----	---	----	---	----	---	----	---	----	---
1913	----	---	----	---	----	---	----	---	----	---
1914	----	---	----	---	----	---	----	---	----	---
1915	16.82	520	----	---	----	---	----	---	----	---
1916	25.99	802	----	---	----	---	----	---	----	---
1917	23.30	722	----	---	----	---	----	---	----	---
1918	15.95	493	----	---	----	---	----	---	----	---
1919	20.45	632	----	---	----	---	----	---	----	---
1920	27.91	861	----	---	----	---	----	---	----	---
1921	27.15	840	23.46	62	----	---	----	---	----	---
1922	25.23	781	27.35	73	----	---	----	---	----	---
1923	18.68	578	20.31	54	20.11	105	----	---	----	---
1924	25.04	773	27.03	72	28.75	150	26.78	83	----	---
1925	16.69	516	18.33	49	19.61	103	16.87	53	----	---
1926	18.00	558	18.41	49	22.40	117	17.42	54	----	---
1927	18.47	572	19.17	51	20.06	105	20.26	63	----	---
1928	33.42	1,031	**39.89	105	36.39	190	32.90	102	----	---
1929	21.13	654	26.79	71	24.64	129	23.29	73	----	---
1930	11.58	359	12.97	34	14.16	74	12.63	39	----	---
1931	15.19	470	16.96	45	17.51	92	16.66	52	----	---
1932	14.96	461	16.17	43	18.16	95	17.41	54	----	---
1933	23.38	721	25.39	67	27.64	145	27.14	85	----	---
1934	21.40	662	21.59	57	28.48	149	24.24	76	----	---
1935	22.24	688	20.37	54	27.83	146	23.73	74	----	---
1936	23.77	731	22.35	59	24.74	129	23.52	73	----	---
1937	24.90	770	21.96	58	26.00	136	27.05	84	----	---
1938	27.51	851	31.97	85	29.83	156	35.33	110	----	---
1939	23.81	737	24.42	65	26.79	140	26.12	81	----	---
1940	21.56	665	23.37	62	25.53	133	23.16	72	----	---
1941	12.43	385	13.36	35	15.41	81	14.22	44	----	---
1942	16.01	495	17.25	46	17.83	93	17.10	53	----	---
1943	20.63	638	23.15	61	21.30	112	20.33	63	----	---
1944	20.08	619	20.04	53	23.12	121	22.38	70	----	---
1945	30.98	959	27.18	72	32.90	172	32.93	103	----	---
1946	19.93	617	21.08	56	22.51	118	21.24	66	21.82	162
1947	21.23	657	19.19	51	24.16	127	21.26	66	22.83	170
1948	22.94	708	22.94	61	22.86	119	23.15	72	21.68	161
1949	15.18	470	15.66	42	16.53	87	15.64	49	15.80	118
1950	17.76	549	18.36	49	20.35	107	19.97	62	20.06	149
1951	26.98	834	28.00	74	30.45	160	29.19	91	29.28	218
1952	29.27	903	29.95	79	32.13	168	28.64	89	30.08	223
1953	23.48	726	26.79	71	26.40	138	22.48	70	24.99	186
1954	22.43	694	22.40	59	25.69	135	25.02	78	24.95	186
1955	22.44	694	22.60	60	23.88	125	23.09	72	22.46	167
1956	26.45	817	30.04	79	28.04	147	30.03	93	27.37	203
1957	13.85	428	15.13	40	13.78	72	13.56	42	13.11	98
1958	22.30	688	26.70	71	25.30	133	----	---	26.19	193
1959	16.70	516	19.19	51	18.78	98	18.05	62	17.78	132
1960	**35.49	1,093	34.83	92	**36.60	191	**36.27	126	**37.92	279
1961	20.89	649	19.75	52	22.53	118	21.20	74	22.26	168
1962	15.45	480	14.47	38	17.03	89	16.21	57	17.03	89
1963	18.36	569	16.94	45	20.72	109	20.05	70	20.68	154
1964	16.30	502	15.61	41	19.55	102	16.70	57	19.43	144
1965	*** 7.04	216	*** 6.52	17	*** 7.60	40	*** 6.69	23	*** 7.96	57
1966	13.33	413	12.14	32	16.30	85	14.15	49	16.05	120
1967	21.37	661	22.15	59	24.20	127	22.76	79	24.73	184
1968	20.86	646	21.74	58	20.78	109	21.32	74	21.30	160
1969	26.49	818	27.54	73	29.97	157	27.65	96	29.23	217

* GAGING STATION RELOCATED BELOW OTTER BROOK LAKE NEAR KEENE, N.H.; D.A. = 47.2 SQ. MI.; 1958-1969

** MAXIMUM ANNUAL RUNOFF FOR PERIOD OF RECORD

*** MINIMUM ANNUAL RUNOFF FOR PERIOD OF RECORD

f. Frequency Analysis.

(1) Peak Discharge Frequency. The frequency of percent chance of occurrence of discharges was determined for selected U.S. Geological Survey gaging stations in the Ashuelot River watershed. Frequency analyses were made in accordance with procedures in ER 1110-2-1450, "Hydrologic Frequency Estimates," dated 10 October 1962. Following a regional frequency analysis, a skew coefficient of 1.0 was adopted for all tributaries of the Connecticut River. Discharge-frequency data for selected Ashuelot River gaging stations is shown in table E-8.

TABLE E-8

NATURAL PEAK DISCHARGE FREQUENCY DATA
(cfs)

Expected Probability Percent Chance	Years	Ashuelot River Near Gilsum	South Br. Ashuelot at Webb	Ashuelot River at Hinsdale
0.50	200	8,100	10,400	31,000
1.0	100	6,400	7,200	24,000
2.0	50	5,000	5,000	19,000
5.0	20	3,600	3,200	13,800
10.0	10	2,800	2,200	10,600
20.0	5	2,200	1,600	8,100
50.0	2	1,600	1,100	5,700
99.0	1.01	1,300	700	4,400

(2) Frequency of Reservoir Filling. Surry Mountain Lake has reached a stage of 22 feet, representing seven percent of available flood control storage, 52 times since beginning of operations in 1941. Otter Brook Lake has reached a stage of 30 feet, representing six percent of available flood control storage 23 times since 1958. A tabulation of these operations, along with the amount of flood waters stored, is given in tables E-9 and E-10. Area capacity table and area capacity and percent full curves are shown on plates E-17, E-18 and E-19 for Surry Mountain Lake and are shown on plates E-20, E-21 and E-22 for Otter Brook Lake.

7. CHANNEL AND FLOODWAY

The Ashuelot River and its two main tributaries converge in a flood plain at Keene. Table E-11 gives the approximate drainage areas of streams that contribute to the flood plain.

TABLE E-9

RESERVOIR OPERATIONS
SURRY MOUNTAIN LAKE

Date	Max. Stage (feet)	Storage Utilized Ac. Ft.	Storage Utilized Percent Total
May 1943	25.8	3,770	12
Nov 12, 1943	38.8	7,720	24
Apr 27, 1944	40.2	11,530	36
Jun 30, 1944	35.4	8,625	27
Sep 17, 1944	23.8	2,930	9
Mar 23, 1945	38.7	10,590	33
Apr 28, 1945	27.0	4,310	14
May 21, 1945	30.0	5,730	18
Jun 23, 1945	28.0	4,760	15
Mar 12, 1946	31.3	6,390	20
Apr 18, 1947	41.5	12,370	39
Mar 29, 1948	57.6	24,800	79
Jan 8, 1949	36.7	9,380	30
Apr 7, 1950	30.1	5,780	18
Nov 30, 1950	42.9	13,310	42
Feb 12, 1951	22.0	2,220	7
Apr 12, 1951	50.3	18,710	59
Nov 9, 1951	30.6	6,035	19
Jan 29, 1952	23.0	2,615	8
Apr 16, 1952	44.0	14,050	44
Jan 29, 1953	25.6	3,680	12
Apr 2, 1953	53.8	21,540	68
Dec 11, 1953	28.1	4,810	15
Apr 20, 1954	28.5	5,000	16
Oct 19, 1955	27.3	4,440	14
Jan 14, 1956	31.0	6,240	20
May 3, 1956	50.6	18,950	60
Dec 24, 1957	27.4	4,490	14
Apr 26, 1958	43.5	13,710	43
Jan 25, 1959	24.0	3,010	9
Apr 6, 1959	36.5	9,250	29
Oct 27, 1959	37.4	9,800	31
Nov 30, 1959	28.7	5,100	16
Apr 7, 1960	54.8	22,380	71
May 27, 1960	23.5	2,810	9
Jun 20, 1960	23.0	2,615	8
Sep 22, 1960	25.6	3,680	12
Apr 28, 1961	24.0	3,010	9
Apr 11, 1962	40.8	11,920	38
Apr 6, 1963	31.8	6,650	21
Jan 27, 1964	27.5	4,530	14
Mar 9, 1964	22.0	2,220	7
Apr 17, 1964	32.9	7,240	23
Apr 18, 1965	26.0	3,850	12
Mar 27, 1966	23.0	2,615	8
Apr 6, 1967	30.9	6,190	20
May 31, 1967	31.0	6,240	20
Mar 25, 1968	44.0	14,050	44
Dec 6, 1968	22.0	2,220	7
Apr 25, 1969	55.5	22,980	73
Feb 5, 1970	22.0	2,220	7
May 20, 1970	23.0	2,615	8

TABLE E-10

RESERVOIR OPERATIONS
OTTER BROOK LAKE

Date	Max. Stage (feet)	Storage Utilized Acre-Feet	Storage Utilized Percent Total
May 1, 1958	66.3	7,920	45
Jan 25, 1959	34.4	1,640	9
Apr 12, 1959	65.0	7,600	43
Oct 27, 1959	54.0	5,120	29
Nov 30, 1959	39.4	2,370	13
Apr 8, 1960	81.8	12,160	69
Sep 14, 1960	35.0	1,720	10
Apr 28, 1961	30.6	1,170	7
Apr 10, 1962	56.9	5,740	33
Oct 8, 1962	32.6	1,410	8
Apr 6, 1963	43.4	3,070	17
Jan 27, 1964	32.6	1,410	8
Apr 18, 1964	43.0	3,000	17
Mar 27, 1966	33.2	1,485	8
Apr 5, 1967	43.8	3,140	18
May 28, 1967	32.0	1,330	8
Dec 14, 1967	30.0	1,100	6
Mar 26, 1968	65.3	7,670	44
Dec 6, 1968	31.0	1,215	7
Apr 25, 1969	82.6	12,400	71
Feb 5, 1970	32.0	1,330	8
Apr 4, 1970	35.0	1,720	10
May 20, 1970	33.0	1,460	8

TABLE E-11

DRAINAGE AREAS
KEENE FLOOD PLAIN

Location	Drainage Area (square miles)	
Ashuelot River at the Branch	114	
The Branch at Ashuelot River	100	
Otter Brook at the Branch		55
Minnewawa Brook at the Branch		33
Local Branch to Ashuelot River		2
Beaver Brook at Ashuelot River		10
South Branch at Ashuelot River	72	
Ash Swamp Brook at Ashuelot River	18	
Local-Keene to West Swanzey	8	
Total at West Swanzey	312	

The flood plain, which begins at the Faulkner and Colony Dam in Keene (toe elevation 463.0 msl) and ends at the Dickinson Dam in West Swanzey (crest elevation 456.2 msl, crest length 168 feet) is the most predominant feature of the Ashuelot River watershed. Refer to plate E-52 for pictures of both dams. Beaver Brook, Ash Swamp Brook, the Branch and the South Branch Ashuelot River all contribute to flows in this 9 river mile flood plain which drops only 6.8 feet.

The meandering river channel has a low discharge capacity due to its small cross sectional area and flat gradients, with the result that floodwaters cause considerable depth of pondage in the plain.

A nonrecording telemark gage, near the Keene sewage pumping station, is the principal index point for the flood plain. Stages at the telemark are caused by a changing series of riverflow conditions. Under normal riverflows, stages are low and are related to the discharge in the Ashuelot River just below the confluence with the Branch. As the flow in the Ashuelot River increases, the storage reach begins to fill. River stages are now caused by a combination of backwater and the flow in the Ashuelot River below the confluence with the Branch. As the flood plain continues to fill during a major flood, the river stages become more and more dependent upon the backwater effect that is caused by the discharges at West Swanzey. As the riverflows return to normal, the effect of backwater diminishes, and the discharges below the confluence again control the fluctuations of the river stages within the flood plain.

A partial stage discharge curve for the West Swanzey dam, shown on plate E-35, has been developed. This curve will assist the Control Center in developing future hydrologic studies in the flood plain during periods of high flow.

8. FLOODS OF RECORD

a. General. Flooding in the Ashuelot River watershed can occur at any time of the year. The floods of November 1927, September 1938, and October 1959 were caused by intensive rainfall, while the flood of March 1936 was caused by heavy rainfall, warm weather and considerable snowmelt.

b. Historic Floods. The flood history of the Ashuelot River watershed extends back approximately 230 years. Information was obtained regarding a number of the most severe floods in this area through field investigations and research of published U.S. Geological Survey data and newspaper accounts. Following is a list of 14 of these historic floods:

December 1738	February 1824	September 1882
March 1801	September 1828	April 1895
February 1807	January 1841	July 1897
July 1813	April 1862	February 1900
March 1818	October 1869	

c. Recent Floods. In recent years, five significant floods have been experienced in the Ashuelot River watershed. These floods occurred in March 1936, September 1938, October 1959, April 1960 and April 1969. The October 1959 flood was centered over Otter Brook while the remaining were watershed-wide events. Flood information for the seven largest floods of record at selected locations in the Ashuelot River watershed are given on the hydrologic information pertinent data sheet on page i at the front of the manual.

(1) March 1936 Flood. The largest volume flood of record in the Ashuelot River watershed occurred between 9 and 22 March 1936. The winter's snow cover in the watershed was heavier than normal, as little thawing had occurred during January and February. A heavy ice cover had formed over long reaches of all streams during the extended period of below freezing weather. Temperatures became unseasonably warm on 9 March and continued so during the remainder of the month. The total rainfall at Keene for the period 9 to 22 March was 5.97 inches. This rainfall, along with a snow depletion of approximately 7 inches, contributed to a runoff of 11.8 inches at Hinsdale for the period 12 to 31 March. Plate E-23 shows the natural flood hydrograph and the hydrograph as modified by both reservoirs.

(2) September 1938 Flood. The greatest peaking flood of record in the Ashuelot River watershed occurred on 21 September 1938 when a hurricane travelled northward through the Connecticut River Valley. This hurricane was preceded by nearly a full week of precipitation which saturated the soil with 1.70 inches of rain between the 13th and 17th. The hurricane itself deposited 7.43 inches of rain at Keene between the 18th and 22nd. The total runoff associated with the storm at Hinsdale, New Hampshire, was 5.2 inches. Plate E-24 shows the natural flood hydrograph and the hydrograph as modified by both reservoirs.

(3) October 1959 Flood. Northern New England experienced abnormal amounts of precipitation during the storm of October 23-26, 1959 and major flooding occurred at some locations. Over 10 inches of rain were recorded at Pinkham Notch in the White Mountains. A total rainfall of 4.57 inches were experienced at Keene and 4.55 inches at Otter Brook Lake for the three-day period.

(4) April 1960 Flood. The month of April opened with deep snow cover over the watershed due to heavy March snowfall and abnormally cold temperatures. The water equivalent in the snowpack ranged up to 10 inches in the headwaters of the upper tributaries. A period of warm weather and moderate to heavy rain began on 30 March and continued with minor interruptions until 6 April. The average rainfall over the basin was nearly 4 inches for that period. The Keene telemark reached a stage of 473.6 feet on the local datum. The Winchester Street gage, which was located immediately downstream of the present Island Street gage and which had the same stage relationship as the Island Street gage, reached a stage of 7.6 feet. The natural would have reached a stage of 10.4 feet. Refer to plate E-25 for the modified and natural flood hydrographs.

(5) April 1969 Flood. The water content in the snow cover preceding the April 1969 flood was extremely high. A maximum water equivalent of 9.6 inches was reached on the first of March. This had depleted only to 6.2 inches by the first of April. The March value was the highest recorded for that date. The monthly rainfall for April at Keene was 3.70 inches, at Surry Mountain Lake 3.14 inches and at Otter Brook Lake 4.37 inches. The 23rd and 24th of the month marked the highest concentration of rain for any 48 hour period. During this period, 1.69 inches fell at Otter Brook, 1.22 inches at Keene and .87 inch at Surry Mountain. The flood resulted in a record volume of water stored at Otter Brook (71 percent) and

a near record at Surry Mountain (73 percent). The total runoff for the month of April at Hinsdale was 9.07 inches. On the 25th, the observed stage at the Keene telemark reached 472.7. The estimated natural stage at the telemark would have been about 475. Photographs of both lakes during the high flood period are shown on plates E-50 and E-51.

9. ANALYSIS OF FLOODS

a. Ashuelot River. Flood flows and precipitation records were analyzed to determine the runoff characteristics of the Ashuelot River watershed such as: time of year when floods may occur, effect of topography, relative timing and flood peak contributions at downstream damage centers on the Connecticut and Ashuelot Rivers. The analysis resulted in the following conclusions: (1) The Ashuelot River watershed responds quickly to periods of intense rainfall which may occur in any month and as a result, there is no flood-free season of the year, (2) the spring snowmelt is not of damaging magnitude unless augmented by rainfall and (3) hilly slopes throughout most of the watershed above and below the Keene flood plain produce rapid runoff.

Highflow duration-frequency curves were determined at selected long term gaging stations throughout the watershed. Refer to Appendix C of the Connecticut Comprehensive Report for further explanation of the data.

The principal flood-producing tributaries in the watershed are Otter Brook and Minnewawa Brook, which unite to form the Branch, Beaver Brook and South Branch. Smaller brooks feeding directly into the Ashuelot River, such as Ash Swamp Brook and Mirey Brook, also contribute to floods.

Otter Brook is effectively controlled by Otter Brook Lake during all floods. Ash Swamp Brook has been modified by the Soil Conservation Service to prevent localized flooding. This project does not significantly affect stages in the Keene flood plain.

Many lakes and ponds scattered throughout the watershed add significant amounts of natural storage for flood protection. The Keene flood plain also provides natural storage to lower flood stages downstream on the Ashuelot and Connecticut Rivers.

Approximate high flow travel times and flood routing coefficients for reaches of the Ashuelot River are shown in the hydrologic pertinent data sheet.

b. Connecticut River. Flooding along the Connecticut River is caused by excessive rainfall, melting snow or a combination of both. Analyses of floods of record reveal that Connecticut River floods have generally originated in one of the following manners: (1) as a general basin-wide flood, usually with snowmelt; (2) in the northern portion upstream of White River Junction; (3) in the central portion between White River Junction and Montague City, and (4) in the southern portion downstream of Montague City. The March 1936 flood was basin-wide, the September 1938 flood originated in the lower and central portions of the basin, the flood of June 1947 occurred in the upper basin and the flood of August 1955 was a lower basin event.

During floods originating in the northern part of the basin, peak flows at the mouth of the Ashuelot River occur earlier than Connecticut River peak discharges at Montague City. With basin-wide floods and those originating in the central portion, the Ashuelot River peak synchronizes with the Connecticut River crest. During floods originating in the southern part of the basin, flood discharges from the Ashuelot River occur on the receding side of the Connecticut River hydrographs. Contributions from the Ashuelot to the Connecticut River depend considerably on the location of the storm.

c. Ice Jam Flooding. The Ashuelot River watershed is subject to periodic ice jam flooding. Jamming has occurred upstream of Surry Mountain Lake at the Polly bridge 3/4 of a mile downstream from the Gilsum gage, at bends and constrictions in a section of Otter Brook just downstream of the Route 101 bridge, at the confluence of the Ashuelot and Branch just downstream of the Keene telemark and in the community of Ashuelot about three miles upstream from the mouth of the Ashuelot River. None of these points have experienced major flooding due to ice jams in the recent years, however, minor flooding can be expected during annual spring runoff. Refer to plate E-3 for location of problem areas.

10. DESIGN FLOODS

a. Spillway Design Flood.

(1) Surry Mountain Design Criteria. In accordance with R&H No. 39, 1936, E.D. 7402, a spillway design flood (SDF) for the project was developed in the"Revised Analysis of Design," July 1939, based on a nonuniform areal distribution of rainfall during the maximum probable storm. The spillway design storm contributed 17.9 inches of rainfall over a 48-hour period contributing a volume of 14.3 inches of runoff.

The unit graph was derived from general relations of topographic features of the watershed. These general relations were defined by a thorough analysis of the unit hydrographs and watershed topography at 22 gaging stations in the Connecticut River basin. The adopted 12 hour unit graph had a peak of 3,000 cfs.

The pool was assumed to be at spillway crest with all gates closed. The inflow peaked at 44,800 cfs and resulted in an uncontrolled spillway discharge of 40,900 cfs.

(2) Surry Mountain 1961 Criteria. In accordance with a letter from the Chief of Engineers, dated 18 January 1961, a study was undertaken to determine the adequacy of the spillway following a rockslide which would partially restrict flow during uncontrolled spillway discharge.

Values of rainfall for the spillway design flood were obtained from Hydrometeorological Report No. 33 "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian," dated April 1956, as prepared by the Hydrometeorological Section of the National Weather Service. The total spillway design storm precipitation for the 100 square mile drainage area above Surry Mountain Lake is 22.2 inches, occurring in 48 hours.

A 3-hour unit hydrograph was developed from computed inflow hydrographs of major floods at Surry Mountain Lake, and increased approximately 25 percent. The resulting unit graph had a peak flow of 4,000 cfs. The inflow to the reservoir, already full to spillway crest, was derived by applying the rainfall excess to the adopted unit hydrograph. The computed peak inflow was 63,000 cfs, equivalent to 630 cfs per square mile. The design flood was routed through surcharge storage, resulting in a maximum spillway discharge of 50,000 cfs and a conduit discharge of 4,000 cfs with a maximum water surface elevation of 562.4 feet, msl. (See plate E-26). Refer to table E-12 for a comparison of spillway criteria.

(3) Otter Brook Design Criteria. Values of rainfall for the spillway design flood were obtained from Hydrometeorological Report No. 28, "Generalized Estimate of Maximum Possible Precipitation over New England and New York," dated March 1952, as prepared by the Hydrometeorological Section, Division of Hydrologic Services, National Weather Service.

The spillway design flood, developed for the hydrology and hydraulic analyses design memo dated June 1955, representing an inflow to the reservoir, already full to spillway crest, was derived by applying the rainfall excess to the adopted unit hydrograph plus an assumed base flow of 100 cfs. The peak of the spillway design flood inflow was 38,000 cfs, equivalent to 810 cfs per square mile.

Assuming all gates are closed, the resulting maximum spillway discharge was 34,500 cfs with a maximum water surface elevation of 797.1 msl, equivalent to 16.1 feet of surcharge.

(4) Otter Brook 1967 Criteria. Pursuant to the authority contained in Engineer Circular 1110-2-34, "Review of Design Features of Existing Dams," dated 1 November 1966, a review was made of the spillway design and real estate acquisitions at the 35 existing dams and lakes in the New England Division to determine whether they conformed adequately with current policies and criteria with respect to safety and functional reliability. Included in this report, which was completed in August 1967, was a determination of the adequacy of spillway discharge capacities and freeboard allowances on existing dams, including Otter Brook Lake. A summary of the original and 1967 hydrologic design criteria can be seen in table E-12. The maximum surcharge elevation, as computed according to the 1967 criteria, is 1.2 feet higher than that given in the original design criteria. Although the minimum 5-foot freeboard requirement is not met, the 3.7-foot freeboard is considered to reasonably meet the safety requirements for freeboard needs. (See plate E-27).

b. Standard Project Flood. A standard project flood was not developed for the July 1939 Surry Mountain Analysis of Design. However, in the Hydrology and Hydraulic Analysis design memo for Otter Brook Lake, a SPF for Keene, New Hampshire, was developed as a demonstration flood to measure the effectiveness of the proposed Otter Brook Lake in combination with the existing Surry Mountain Lake. Since the flood was to be used for demonstration rather than design purposes, it was determined by an approximate method. A rainfall value at Keene of 11.3 inches, which equals approximately 60 percent of the maximum possible rainfall for an area of 310 square miles, was selected for the standard project storm.

Rather than develop unit hydrographs for the component areas, the hydrographs of the September 1938 flood were selected as typical and were adjusted to equal the selected project storm runoff. The standard project flood for Keene, representing the total of the composite inflows to the Keene flood plain, had a maximum computed discharge of 42,000 cfs which is 35 percent greater than the record flood of September 1938. The inflow as modified by Surry Mountain and Otter Brook would peak at 24,000 cfs.

The effect of Otter Brook and Surry Mountain Lakes on this standard project flood is shown on plate E-28. Neither reservoir has sufficient capacity to contain the entire flood but the spillway discharges occur on the recession side of the downstream flood hydrographs and do not contribute to the peak river stages during the flood. The stage reduction in the Keene flood plain is about 4.5 feet. Pertinent data on this standard project flood at Surry Mountain and Otter Brook Lakes is given in table E-13.

TABLE E-12

SPILLWAY DESIGN CRITERIA

Item	Surry Mountain Lake: Design Criteria	Surry Mountain Lake: 1961 Criteria	Otter Brook Lake: Design Criteria	Otter Brook Lake: 1967 Criteria
SPILLWAY DESIGN STORM				
Basis of Design	R&H No. 39	HR No. 33	HR No. 28	HR No. 33
Volume of Rain (in. 48 hrs.)	17.9	22.2	24.2	19.1
Losses (in. 48 hrs.)	3.6	3.2	3.2	3.2
UNIT HYDROGRAPH				
Unit Rainfall Duration (hrs)	12	3	3	3
Peak Flows (cfs)	3,000	4,000	2,080	3,300
SPILLWAY DESIGN FLOOD				
Peak Inflow (cfs)	44,800	63,000	38,000	45,000
Peak Outflow (cfs)	40,900	54,000*	34,500	41,500*
Volume of Runoff (ac.ft.)	76,200	104,500	53,000	44,800
S.D.F. RESERVOIR REGULATION PLAN				
Initial Pool Elev. (ft, msl)**	550.0	550.0	781	781
Outlet Facil. During Flood	Closed	Operable	Closed	Operable
Max. Surcharge Elev. (ft, msl)	560.0	562.4	797.1	798.3
FREEBOARD CHARACTERISTICS				
Design Wind Velocity (mph)	80	80	80	80
Effective Fetch (miles)	2.25	0.93	1.7	0.52
Average Depth (ft)	-	50	-	85
Wave Runup (ft)	3.5	3.95	4.6	3.0
Wind Tide (ft)	-	0.2	0.3	Negligible
Adopted Freeboard (ft)	5.0	5.6	4.9	5.0

* Surry Mountain: 50,000 Spillway Discharge, 4,000 Conduit Discharge
Otter Brook: 40,000 Spillway Discharge, 1,500 Conduit Discharge

** Pool Initially Full to Spillway Crest Elevation

TABLE E-13

STANDARD PROJECT FLOOD
FOR KEENE, NEW HAMPSHIRE

	Surry Mountain	Otter Brook
Maximum reservoir inflow - cfs	13,000	7,000
Maximum reservoir outflow - cfs	4,800	1,200
Maximum water surface elevation - msl	552.3	782.5

In October 1970 a study was undertaken to determine the effects of utilizing a portion of the flood control storage for water quality releases on a seasonal basis at Otter Brook Lake. A standard project flood, centered over Keene, was developed for this study. In all respects this storm was less intense than the original SPF of the design memo. The revised 24 hour storm rainfall totaled 9.1 inches at Keene with a resulting runoff of 7.3 inches. The maximum inflows at Surry Mountain and Otter Brook Lakes were 10,370 cfs and 5,770 cfs, respectively; the maximum spillway discharges were 2,480 cfs and 350 cfs, respectively. The maximum natural discharge into the Keene flood plain from all contributing sources for the revised SPF was 34,000 cfs as compared to 42,000 cfs for the original SPF. The peak at the Keene telemark as modified by Surry Mountain and Otter Brook would be 22,000 cfs for the revised SPF as opposed to 24,000 for the original Design Memo SPF.

11. FLOOD DAMAGES

a. Flood of September 1938. The record flood of September 1938 caused damages in the Ashuelot River basin amounting to $1,138,000. The heaviest losses occurred in the densely populated areas along the banks of the Ashuelot River and Beaver Brook. Some 372 properties, including 347 homes, 15 commercial firms and 10 industrial plants, experienced losses along Beaver Brook amounting to $218,000.

b. Recurring Losses. A recurrence of the record flood levels of September 1938 on the Ashuelot River under 1971 conditions would cause losses estimated at $8,856,000. Of these losses, $6,248,000 would occur in the city of Keene. The operation of Surry Mountain and Otter Brook Lakes would reduce these losses by $5,809,000.

12. DROUGHTS

a. General. The Ashuelot River watershed lies within the general zone classified as humid, where the average annual precipitation is distributed reasonably well throughout the year. In National Weather Service terminology, a drought is considered to be a period of 14 or more days in which less than 0.1 inch of precipitation falls in a 48 hour period. To the agriculturist, a drought is a lack of soil moisture during the growing season. Hydrologically, a drought is defined as a prolonged period of precipitation deficiency which seriously affects riverflow as well as surface and ground water supplies. Periods of deficient precipitation and runoff have occurred during the past in the basin.

b. History. The drought history in the watershed extends back more than 100 years. Several periods of below average precipitation have occurred prior to 1960, although none have caused a serious impact on the water needs of the area due to the sparse population and lack of industry in the region. The most notable of these occurred from 1880 to 1883, 1930 to 1932, 1941 to 1942 and 1948 to 1950.

c. Drought of 1961-1966. The longest and most severe drought in the history of the Connecticut River basin is the one of 1961-1966. During this period, the cumulative precipitation deficiency at Keene was about 34.9 inches, which is nearly equal to the average annual precipitation of 38.5 inches. The cumulative runoff deficiency for water years 1961-1966 amounted to 33.9 inches at Hinsdale which is about 162 percent of the average annual runoff of 20.9 inches. Rarely is a deficiency of groundwater carried over from one growing season to the next in New England, since it is replenished during each spring runoff. However, this condition occurred in the winter of 1964 to 1965 and resulted in a record lowflow runoff of 7.04 inches at Hinsdale in water year 1965, which is about 34 percent of the average yearly runoff.

13. REGULATION STUDIES

a. Low Flow Augmentation. Studies are presently underway to determine the feasibility of utilizing portions of Otter Brook Lake flood control storage, on a seasonal basis, for water quality releases. Two inches of storage (5,000 acre-feet) could be used during the summer to augment lowflows in Otter Brook. Two automatic water quality monitors will be installed, one in Winchester, New Hampshire, and one at Otter Brook Lake. These monitors will be tied into NED's Automatic Hydrologic Radio Reporting Network to assist RCC in determining release rates necessary to meet downstream commitments.

CHAPTER III

COMMUNICATIONS

14. GENERAL

All communications between the dam operator and RCC are made via the NED radio network during normal work hours or when NED headquarters is otherwise manned. Whenever the radio network is inoperative, communications are made by telephone. During nonwork hours, reports and regulation instructions are issued by telephone to or from the homes of RCC personnel. A telephone directory is maintained by RCC and updated yearly for use by those associated with reservoir regulation functions. In the event of failure of the NED radio network and telephone service, emergency communications will be attempted through the State Police or Civil Defense radio facilities. In addition, radios located in the Automatic Hydrologic Radio Reporting Network facilities in the field are tied directly to the RCC computer room serving as a backup system for normal radio communication.

15. PRECIPITATION REPORTING NETWORK

Reports of precipitation data from the Ashuelot River watershed are used primarily for the purpose of alerting regulation personnel and of providing a basis for appraising the severity of the storm. The collection and reporting of precipitation data from Surry Mountain and Otter Brook Lakes is the responsibility of the respective dam operators. The operators also received calls from some of the key observers in the immediate area.

The Reservoir Control Center periodically reviews network arrangements to insure that an adequate reporting network is maintained. The River Forecast Center in Hartford, Connecticut, receives precipitation reports from observers in and near the Ashuelot River watershed, which are made available to RCC upon request. In addition, cooperative reporting procedures from all Corps' dams have been established with the River Forecast Center and have been detailed in separate memos to each operator. Locations of the NED and the National Weather Service precipitation stations are shown on plate E-3.

16. RIVER REPORTING NETWORK

a. General. A network of river stage observation stations, which is part of an overall river reporting system for the Connecticut River basin, has been established. This network assists in the execution of the reservoir regulation plan by permitting personnel in RCC or at the dams to obtain river stages at selected key index stations located either on tributaries or on the Connecticut River.

b. River Reporting System. The river reporting system in the Ashuelot River watershed consists principally of the following stations in downstream order: (a) the staff gage on the Island Street bridge in Keene; (b) the telemark gage near the Keene pumping station; (c) the gage on the Homestead Woolen Company dam in West Swanzey; (d) the staff gage downstream of the highway bridge in Winchester. The location of these stations can be seen on plate E-3. The Montague City telemark on the Connecticut River is also used in the river reporting system. These observations are obtained either by the dam operators or by local observers. Complete information concerning other key locations on the Connecticut River and its tributaries are obtained from other operators of flood control projects and the NWS River Forecast Center at Hartford, Connecticut.

17. AUTOMATIC HYDROLOGIC RADIO REPORTING NETWORK

The effective regulation of flood control projects in New England, consisting of 35 flood control dams and 4 hurricane barriers, requires a reliable and rapid method of collecting and coordinating hydrologic data by the Reservoir Control Center. The installation of an Automatic Hydrologic Radio Reporting Network has been completed.

Radio gaging stations have been established at the following locations in the Connecticut River basin:

Passumpsic River at Passumpsic, Vermont
Connecticut River at Wells River, Vermont
White River at West Hartford, Vermont
Connecticut River at White River Junction, Vermont
Connecticut River at North Walpole, New Hampshire

Deerfield River at West Deerfield, Massachusetts
Connecticut River at Montague City, Massachusetts
Conant Brook at Monson, Massachusetts
Chicopee River at Indian Orchard, Massachusetts
Westfield River at Westfield, Massachusetts

Connecticut River at Springfield, Massachusetts
Mad River Lake at Winchester, Connecticut
Farmington River at Collinsville, Connecticut
Farmington River at Rainbow, Connecticut
Connecticut River at Hartford, Connecticut

Details of the radio hydrologic reporting network are covered in the "Guidance Memorandum, Reservoir Control Center, September 1971," and will also be covered in the "Connecticut River Master Manual of Reservoir Regulation."

18. REPORTS

a. Weekly Reports. The dam operator makes a routine report by radio (or telephone) to RCC each Friday morning. This report insures continuous contact between the operating personnel and the RCC and also serves as a check on the communications network. The report includes the preceding 24 hour precipitation, current weather conditions, reservoir pool stage, regulation data, river conditions at index stations, and other miscellaneous data. A sample of the completed form is shown on plate E-29.

b. Alerting Reports. An alerting report is promptly made and includes pertinent data that is readily available along with a general appraisal of local conditions although data from all the precipitation or flood index stations may not be available. Whenever any of the following conditions occur, the dam operator will immediately notify RCC.

(1) Precipitation. Occurrence of 1 inch of precipitation during a 24-hour period at either lake or at any precipitation station within the watershed.

(2) Reservoir Stages.

(a) Nonfreezing Season. A reservoir stage of 18 feet and rising at Surry Mountain Lake or a reservoir stage of 21 feet and rising at Otter Brook Lake.

(b) Freezing Season. A reservoir stage of 19 feet and rising at Surry Mountain Lake or a reservoir stage of 24 feet and rising at Otter Brook Lake.

(3) River Stages. Whenever the Ashuelot River at the Keene telemark rises to an elevation of 468 feet and is rising.

(4) Unusual Conditions. Unusual local conditions such as difficulty with the gates, ice jams, excessive debris, bridge failures, etc., will be reported.

c. Supplemental Reports. Supplemental radio (or telephone) reports are made to RCC by the dam operator either following instructions from RCC or if it appears that flood conditions might develop in the watershed as the result of melting snow, ice jams, dam failures or heavy localized rainfall. The time and frequency of these reports are dependent upon the severity of conditions and specific instructions from RCC. Flood reports are transmitted at minimum 3-hour intervals. Plate E-30 shows a typical reporting log which indicates the data to be included in reports by the dam operator during flood periods. Insofar as practicable, the following information is included in the flood report to RCC.

(1) Precipitation at Dam. The total amount of precipitation which has fallen up to the time of reporting and several intermediate amounts with times of observation.

(2) Reservoir Stage. The pool stage at time of reporting and several previous readings with corresponding times to determine the rate of rise and define the inflow hydrograph, accurate readings of stage and time are essential to facilitate computations by RCC. (See plates E-32 through E-34, inclusive).

(3) Gate Positions. Gate openings and discharges at time of reporting and at beginning of storm. Any gate changes since preceding report should be included with corresponding stage and discharge.

(4) Precipitation Reports from Observers. Rainfall data received from cooperative observers.

(5) River Stages. Ashuelot River stages with times of observations from gage at Keene telemark and other stations as requested.

(6) Snow Cover. General snow cover which may affect runoff conditions throughout the basin.

(7) Miscellaneous Data. Any other information which might be pertinent, such as temperature, etc.

d. Special Reports. A special report is submitted by the dam operator to RCC whenever unusual circumstances occur during a flood or as requested by RCC. The report may be written in longhand and should describe the subjects outlined below if appropriate.

(1) Observations at Dam. The dam operator makes general observations of conditions occurring at the outlet works as listed below. The observations are entered in the log book at the dam. If possible, photographs are taken of any unusual conditions, noting the date, time, the reservoir gage heights and position of the gates.

(a) Extent and action of eddies and waves in the vicinity of the conduit intakes and portals.

(b) Extent and action of turbulence or eddies downstream of the spillway and outlet works.

(c) Effect on the flow through the gates due to an accumulation of ice or debris at the intake.

(d) The pool elevation and position of the gates at which vibration may develop.

(e) Any other unusual hydraulic phenomena that may occur.

(2) Observations at Downstream Control Points. During periods of reservoir regulation, particularly while emptying the reservoir, reconnaissance of downstream conditions is made by either dam operator upon specific authorization of RCC to obtain further data on the safe channel capacity in any of the downstream damage areas or control points.

e. Snow Survey Reports. Snow courses have been established at selected locations within the reservoir watershed. Weekly surveys are made by the flood control dam operator during the winter and early spring to determine the depth of snow and its equivalent water content. Dates for surveys are established each year by RCC so as to correspond with monthly bulletins of the U.S. Geological Survey and supplemental data from power companies. The report will contain the name of the station, the snow depth and water equivalent.

19. SPECIAL ADVISORIES

In accordance with regulations set forth in EM 500-1-1, "Domestic Emergency Operations" and the "Guidance Memorandum, Reservoir Control Center," special advisories from RCC on flood potential and progress of all threatening storms are submitted to the Division Engineer and to the Chiefs of Engineering and Operations Divisions. Flood reports also are prepared for OCE by the Reservoir Control Center.

20. MAINTENANCE OF LOG

All reports, instructions, records of unusual circumstances at the dam, and information pertinent to regulation of the reservoir are entered in the logs. A log is maintained by both the dam operator and Reservoir Control Center.

21. GATE OPERATION RECORD

All gate operations are carefully noted on NED Form 90, a sample of which is shown on plate E-31 and submitted weekly to RCC. All operations are noted regardless of the duration of the change in gate position. The report includes date and time of day, reservoir stage, outflow, precipitation, gate opening, tailwater reading and remarks column.

CHAPTER IV

HYDROLOGIC FORECASTS

22. WEATHER AND RIVER FORECASTS

a. Precipitation Forecasts. In addition to the normal weather forecasts, quantitative precipitation forecasts, prepared by the National Weather Service (formerly U.S. Weather Bureau), are received daily over the Massachusetts Weather Teletype Network by RCC. Supplemental weather information and forecasts prior to or during floods are made available upon request from the Concord, New Hampshire and Boston, Massachusetts, offices.

b. River Forecasts. The National Weather Service River Forecast Center at Hartford, Connecticut, is responsible for preparing and disseminating flood forecasts for the Connecticut River and some of the principal tributaries. The Center also prepares and transmits biweekly forecasts by teletype to RCC indicating the amount of 12 hour rainfall necessary to produce flood conditions on selected tributaries. Although flood forecasts are not specifically given for the Ashuelot River, they are given for nearby watersheds and are indicative of hydrologic conditions in the area. Flood forecasts are also given for the Connecticut River at the following locations: Wells River, White River Junction, North Walpole and Montague City.

c. Existing Corps of Engineers Flood Forecasts. Curves have been developed as a guide for estimating rainfall-runoff relationships for Corps' use only. Curves of Keene rainfall versus estimated peak discharges into the reservoirs have been determined from available information and are shown on plate E-36. These curves will be checked with future data and modified, if necessary, to improve the correlation.

d. Future Corps of Engineers Flood Forecasts. The Master Manual for the Connecticut River basin has been initiated and will include procedures for flood forecasting (for Corps' use) and releasing of stored waters from the entire reservoir system following a flood.

In December 1971, the Reservoir Control Center requested the Hydrologic Engineering Center to initiate studies to develop a flood forecasting technique for the Merrimack River basin based on real time data collected from the Automatic Radio Reporting Network, dam operators and other sources. Results and findings of this study will be applied to the entire Connecticut River basin.

CHAPTER V

RESERVOIR REGULATION

23. PLAN - GENERAL OBJECTIVES

The general objective of the regulation procedures for the Ashuelot River watershed is to provide a comprehensive tool for guiding those responsible for operating Surry Mountain and Otter Brook Lakes in accomplishing the missions for which these projects were authorized. This plan will allow for the most efficient protection of immediate downstream communities on the Ashuelot River and communities further downstream on the Connecticut River. This plan will also make efficient use of water available on a seasonal basis for recreation without adversely affecting the flood storing capability of the lakes.

24. NON-FREEZING SEASON

a. Surry Mountain Lake. A permanent recreation pool, about 15 feet deep, is maintained by the concrete weir located immediately upstream of both flood control gates. The normal setting for both conduit gates is 3 feet with the weir gate closed. There is no change in the gate settings for fluctuations in pool stages up to 18 feet; at that time, the Reservoir Control Center is notified.

b. Otter Brook Lake. A recreation pool is maintained at a stage of about 18 feet by the control weir and stoplogs located immediately upstream of the center flood control gate. The two outside gates are closed and the center gate remains fully open. The gates stay in this position until the pool reaches a stage of 21 feet, at which time the RCC will be notified.

25. FREEZING SEASON

a. General. The Reservoir Control Center will instruct the operators when the winter pools are to be established in the fall and drawn down in the spring.

b. Surry Mountain Lake. The weir will be submerged with the pool stage maintained at about 17 feet to keep the flood control gates free from ice. The 2 feet x 3 feet weir gate will be fully opened in order to be used during the spring drawdown. One flood control conduit gate will be closed and the other gate will be partially open to maintain the winter pool. If the pool reaches a stage of 19 feet, RCC will be notified. In the early spring, RCC will notify the operator of the dam to lower the winter pool. Consideration should be given so that the reservoir ice does not break the log boom. This drawdown will entail the release of approximately 560 acre-feet. This could be done at a release rate of 140 cfs above inflow rate for 48 hours. RCC will specify the rate of drawdown.

c. Otter Brook Lake. The weir will be submerged with the pool stage maintained at about 20 feet. The center gate and one of the outside gates will be closed. The other outside gate will be partially open to maintain the winter pool. If the pool reaches a stage of 24 feet, RCC will be notified. RCC will notify the dam operator when to lower the winter pool. Consideration should be given so that the reservoir ice does not break the log boom. A total of 150 acre-feet will be released. This could be done at a rate of 75 cfs above the inflow rate for 24 hours. RCC will specify the rate of drawdown.

26. FLOOD CONTROL

a. Objective. The flood control objectives of both Surry Mountain Lake and Otter Brook Lake are primarily to provide flood protection for the community of Keene and secondly to protect other downstream communities on the Ashuelot and Connecticut Rivers.

b. Operating Constraints.

(1) General. The limitation imposed on the discharges from both Surry Mountain and Otter Brook Lakes, due to the limited channel capacity in Keene, is a constraint at both projects.

(2) Recreation Area.

(a) Surry Mountain Lake. Consideration should be given to try and prevent inundation of the recreation comfort station which begins at a stage of about 23 feet.

(b) Otter Brook Lake. Damage to the recreation comfort station begins at a stage of about 30 feet and consideration should be given to prevent inundation of the station.

27. FLOOD PERIOD

a. General. Regulation of flows from Surry Mountain and Otter Brook are initiated for heavy rainfall occurring over the Ashuelot watershed and also for specific river stages at key Ashuelot and Connecticut River index stations. Regulation may be considered in three phases during the course of a flood. Phase I, the appraisal of storm and river conditions during the development of the flood leading to the initial regulation; Phase II, regulation of the project while the Ashuelot River and/or Connecticut River floodflows crest and move downstream; Phase III, emptying the reservoir following the downstream recession of the flood. The standard operating procedures (SOP) for regulating the reservoirs are shown on plate E-37.

b. Phase I - Initial Regulation of Discharge. During this phase, it is important to collect rainfall and discharge data in order to appraise the development and magnitude of a flood in the basin. Gate operations at Surry Mountain and Otter Brook will be initiated to restrict the reservoir discharge in accordance with the curves shown on guide "A", plate E-38 that prescribes the total release from the reservoirs in which the discharge from Otter Brook is generally one-half that from Surry Mountain. Gates will be completely closed at both projects for the following conditions:

(1) Whenever a rainfall of two inches occurs within a 24-hour period at either lake or at one of the cooperative rainfall stations.

(2) Whenever elevations and rates of rise at the Keene telemark gage occur as follows.

Elevation (feet)	Rate of Rise (feet per hour)
471	0.4 or more
470	0.6 or more
469	0.8 or more
468	1.0 or more

(3) To restrict the contribution from the reservoirs when the forecast stage at Montague City approaches flood stage of 28 feet during the growing season and 30 feet during the non-growing season.

c. Phase II - Continuation of Regulation. An important regulation activity during this period is the collection of hydrologic data such as (1) precipitation amounts throughout the entire watershed as well as surrounding areas; (2) snow cover and water content in case of spring floods; (3) stage and discharge values at downstream control points; (4) other pertinent data which would assist in the regulation. During this phase, the reservoir discharge is regulated to reduce downstream flooding on the Ashuelot and Connecticut Rivers.

As a flood develops, considerable judgement and experience are necessary to vary the regulation in accordance with the amount of residual reservoir storages, river stages in Keene, water content of snow, if any, remaining on the watershed, and weather forecasts. In general, the continuation of regulation will be governed principally by the reservoir pool stages and the elevations at the Keene telemark as shown by the series of guide curves on plate E-38. Guide "B" shows the relationships that exist between the Island Street stages and Surry Mountain releases, with different elevations at the Keene telemark. Guide "C" shows the allowable releases from the Surry Mountain Lake with different pool stages during the growing and non-growing season. It reflects the relationships shown in "B", along with the residual storage in Surry Mountain, and the seasonal channel capacities. Guide "D" shows the releases from Surry Mountain as a percentage of the total reservoir releases.

Secondary river rises from additional rainfall or snowmelt will be considered applicable to Phase II. With rising stages at the telemark gage in Keene, consideration will be given to the travel times from the dams to Keene in order to anticipate river stages. An approximate 4 to 6 hour travel time from Surry Mountain Lake to the telemark and a travel time of about 3 to 4 hours from Otter Brook Lake have been found applicable.

The preceding conditions will usually govern the continuation of regulation in Phase II, but in some cases flood conditions on the Connecticut River will be the controlling factor. Regulation in Phase II will continue until the RCC has determined that the flood peak has passed Montague City and no longer poses any danger to the immediate areas on the Ashuelot and Connecticut Rivers. Approximate travel times for the watershed are given in the hydrologic information pertinent data sheet.

Data used to determine the stage discharge relationship at West Swanzey dam is based on limited observations. It will therefore be necessary to take observations at the dam to further develop the curve. RCC will instruct one of the head operators to obtain readings from the staff gage located on an I-beam beneath the Homestead Woolen Company plant. The U.S. Geological Survey will also be requested by RCC to make river stage measurements during highflow periods.

There are three hydro-electric plants on the main stem of the Connecticut River that the New England Power Company operate. Wilder, Bellows Falls and Vernon are affected by controlled releases from Corps flood control reservoirs. Only Wilder can release large amounts from storage that could adversely affect our operations. Releases will be coordinated with the New England Power Company during flood periods.

d. Phase III - Emptying the Reservoirs. Following the recession of the flood peaks at downstream index stations of the Ashuelot River, the reservoirs will be emptied as rapidly as possible in accordance with the guide curves on plate E-38. Except under unusual flood conditions, the releases from Surry Mountain Lake during the growing season shall not exceed a flow of 800 cfs, and during the rest of the year shall not exceed a flow of about 1,200 cfs. The release from Otter Brook shall not exceed a flow of 600 cfs. The following river stages will also govern the release rates from both reservoirs in accordance with plate E-38.

(1) Island Street. Gage located 0.7 mile downstream of Faulkner and Colony Dam. Stage = 6.5 feet, river well within banks but seepage starts to affect cellars. See plate E-38 for relationship between Surry Mountain discharges and stages at the telemark and Island Street.

Stage = 7.0 feet, river still within banks, water table is raised, seepage affects more cellars. This should be the normal maximum stage.

Stage = 7.5 feet, river still within banks, seepage continued as the water table is even higher. This is the highest stage that should be reached and used only when heavy snow cover exists in the drainage area above Surry Mountain Lake.

(2) Keene Telemark. An elevation of about 472.5 (Keene datum) at the telemark gage near the Keene sewage pumping station. Nuisance damage commences at this elevation with material damage starting at about 474. Keene datum is 5.3 feet above msl.

(3) Winchester, New Hampshire Gage. Flood stage is 15 feet at the staff gage located just downstream of the highway bridge in Winchester. However, past experience has shown that operating for non-damaging stages at the Keene telemark provides non-damaging stages in Winchester.

(4) Montague City, Massachusetts. Flood stage - 28 feet at the Montague City U.S. Geological Survey gage on the Connecticut River during the summer growing season and 30 feet during the non-growing season.

The rate of increase in reservoir discharge from Surry Mountain shall not exceed 200 cfs per 2-hour period for discharges up to 600 cfs and 100 cfs per 2-hour period for discharges over 600 cfs. The maximum rate of reservoir drawdown should not exceed 5 feet per 24 hours. The rate of increase in reservoir discharge from Otter Brook shall not exceed 200 cfs per 2-hour period with the maximum rate of drawdown not to exceed 10 feet per 24 hours. Plates E-39 through E-42, inclusive, show the outlet rating curves for the Surry Mountain and Otter Brook Lakes. Following the emptying of the lakes, the gates will be set at their normal openings.

Evacuation of the water stored in Surry Mountain and Otter Brook Lakes will be coordinated with releases from other projects in the system in a manner that will allow the Connecticut River flood crests to continue receding. This subject will be described in detail in the "Master Regulation Manual for the Connecticut River Basin."

Assuming that the flood control storage at Surry Mountain Lake was filled to capacity of 31,680 acre-feet at elevation 550.0, and with an inflow of 3 csm and an outflow of 1,200 cfs, it would require about 17.5 days to empty the lake to the recreation pool elevation of 500 feet, msl.

Assuming that the flood control storage at Otter Brook Lake was filled to capacity of 17,600 acre-feet at elevation 781.0, and with an inflow of 3 csm and an outflow of 600 cfs, it would require about 19.5 days to empty the lake to the recreation pool elevation of 701 feet, msl.

Secondary river rises during Phase III, due to either additional rainfall or snowmelt, may result in the regulation procedures reverting to Phase II.

e. Regulation for Snowmelt. Moderately high springtime discharges can occur as a result of melting snow, but runoff from this source alone has not caused major flooding. The snow cover in the lower elevations of Massachusetts and Connecticut usually diminishes before melting takes place in the northern areas of Vermont and New Hampshire. However, the potential snowmelt flood threat period on the Connecticut River and its tributaries is prolonged and generally occurs in March and April because of high riverflows and saturated ground conditions.

Active snowmelt begins when the density of the snowpack rises above 30 percent, i.e., a 10-inch depth of snow having 3 inches of water equivalent. RCC has not developed precise correlations regarding high temperatures-snow density-peak runoff relationships for each tributary. However, operating experience has indicated that after the snowpack becomes "ripe", several days of maximum temperatures in the 50's and 60's would result in flows of up to 10 csm in the main stem of the Ashuelot and Connecticut Rivers, and discharges up to 20 csm from the smaller, steeper tributaries in the Ashuelot watershed. The runoff from snowmelt alone is diurnal, orderly and gradual, and regulation by RCC personnel will not necessarily follow the release guides established for runoff associated with rainfall. Regulation during periods of snowmelt alone generally will be based on maintaining releases consistent with downstream channel capacities.

f. Spillway Discharge. Ordinarily during a major flood, the gates will not be opened to avoid spillway discharge. Surcharge storage above the spillway crest will be utilized if the downstream channel capacity continues to be exceeded by the runoff from uncontrolled areas. However, if the stage in either reservoir continues to rise above the crest with the possibility of the pool rising above the maximum design surcharge, the following schedule will be used as a guide for gate releases during spillway discharges.

Surry Mountain Lake		Otter Brook Lake	
Pool Stage	Gate Openings	Pool Stage	Gate Openings
65	0'-0'	98	0'-0'-0'
72	0'-0'	109	0'-0'-0'
73	2'-2'	110	2'-2'-2'
74	5'-5'	111	3'-3'-3'
75	10'-10' (fully open)	112	4.5'-4.5'-4.5' (fully open)

The spillway rating curves are shown on plates E-43 and E-44.

g. Alerting of Flood Affected Populace. Whenever it is anticipated that the pool in either lake will rise above spillway crest elevation during an extreme flood, the operator of that lake will notify the New Hampshire State Police at the Keene barracks during work hours and at the Concord barracks during non-working hours. He will also notify the Keene Director of Public Works of the expected uncontrolled spillway discharge conditions. Phone numbers are located in the RCC telephone directory, which is updated annually.

(1) The operator at Surry Mountain is also responsible for notifying any persons holding leases in the lake area who would be affected by inundation whenever the pool is expected to rise above spillway crest elevation. A list including all the names, addresses and telephone numbers of these persons should be updated periodically by the head operator.

(2) The operator at Otter Brook has no responsibility for notifying persons in the lake for there are no leasing arrangements in the project.

h. Effect of Regulation on Roads Within the Reservoirs. There are several roads that pass through the reservoir areas that are subject to inundation during the storage of floodwaters. Inasmuch as public safety is involved in the use of the roads, the dam operators are responsible for seeing that these roads are barricaded whenever necessary.

(1) Surry Mountain Lake. When a rising pool approaches a stage of 18 feet, the dam operator will consider barricading the access road to the recreation weir (lowest parking area stage about 20 feet). This road is normally barricaded during the winter months. When a rising pool is expected to reach a stage of 35 feet, the dam operator will consider barricading the old Surry Road north of Surry Village. At a stage approaching 50 feet he will consider barricading Old Pond Road. Refer to plate E-6, reservoir map, for location of barriers.

(2) Otter Brook Lake. The access road to the recreation area is barricaded by the State of New Hampshire's Department of Resources and Economic Development, Division of Parks, during the fall, winter and spring months, and during the summer months on rainy days and every evening. In addition, when a rising pool is expected to reach a stage of 27 feet, the dam operator will consider barricading the road to the lowest parking area, stage about 30 feet. Refer to plate E-7 for barrier locations.

28. EXTRAORDINARY FLOOD CONDITIONS

It is conceivable that extraordinary and unpredictable flood conditions may arise, such as dam or bridge failures, highway or railroad washouts, ice jams or debris deposits. Since the prime purpose of the reservoirs is to prevent or reduce further damage, regulation during such unusual conditions may not follow previously described rules but will be governed by the urgency of the circumstances. Time permitting, the RCC will be notified immediately of any unusual incident so that prompt action may be taken and the gates operated to provide maximum protection.

29. REGULATION WITH FAILURE OF COMMUNICATION

Should both the Surry Mountain and Otter Brook operators be unable to contact the RCC when a flood is developing, the Surry Mountain operator has full authority to act promptly in accordance with the instructions contained in the SOP and will direct the regulation of both reservoirs until communications can be established. Should the head operator at Surry Mountain be unavailable for duty, the Otter Brook head operator will direct the regulation of both projects according to the SOP. Refer to plate E-37 and paragraph 30. It should be emphasized that whenever communications fail, or due to lack of adequate reports, it is impossible to fully appraise the runoff from an intense storm; it is preferable to immediately restrict or completely stop the reservoir discharge than to delay regulation and actually contribute to downstream flood conditions.

In cases of extreme emergency, the operator shall attempt to communicate with the RCC through the New Hampshire State Police and the office of Civil Defense Mobilization radio networks. In addition, all hydrologic radio reporting stations have radios that transmit directly to RCC. Paragraph 17 gives the location of these stations.

The Surry Mountain operator will regulate the discharges from both reservoirs very conservatively during Phase I, especially if it is difficult to obtain necessary information on flood conditions. In the case of any doubt as to whether a partial gate or complete closure should be made, the gates will be closed completely whenever the severity of the storm and/or lack of information concerning downstream conditions warrant such action.

In the event that the Otter Brook operator is unable to contact either the RCC or the Surry Mountain operator by phone, he or his assistant will drive to Surry Mountain Lake to report on flood conditions. Should conditions be such that immediate reduction of the Otter Brook outflow is essential, the Otter Brook operator has full authority to make the necessary gate adjustments prior to reporting to Surry Mountain. Releases for emptying the reservoirs will not be made until contact has been established with the RCC. Possession of the instructions contained in this manual does not relieve the dam operator of his responsibility for continued efforts to communicate with the RCC.

30. EMERGENCY OPERATING PROCEDURES (EOP)

When unable to contact the RCC and flood conditions develop, the flood control dam operators have full authority to regulate the gate openings in accordance with instructions as follows:

EMERGENCY OPERATING PROCEDURES

a. Complete Gate Closure for any of the Following Conditions.

Gate Settings: Surry Mountain 0'-0.1'
Otter Brook 0'-0.1'-0'

(1) If two inches of rainfall occur at any of the rainfall stations in the watershed during any 24-hour period.

(2) If the Keene telemark rises to a stage of 471.5 feet (local datum) and is still rising.

(3) If the Connecticut River at Montague City rises to a stage of 25 feet.

b. Emptying the Reservoir. Emptying the reservoir shall not be initiated until contact has been established with RCC.

31. COOPERATION WITH DOWNSTREAM WATER USERS

It is the policy of the Corps of Engineers to cooperate whenever possible with downstream water users and other interested parties or agencies. The flood control dam operator may be requested by downstream users to deviate from normal regulations for short periods of time. Whenever a request for such modification is received, the operator shall ascertain the validity of the request and obtain assurance from other downstream water users that they are agreeable to the proposed operation. The operator will then relay the information to the RCC and request instructions. The minimum release from both projects for downstream fishlife shall not fall below 10 cfs unless the inflow is less than 10 cfs; in this case, the inflow will be passed entirely.

32. ABSENCE FROM DAM

The RCC is notified whenever the head operator expects to be away from the dam either overnight or for an extended period.

33. SEDIMENTATION

Sedimentation ranges and monuments have been installed in the reservoir areas and can be seen on plates E-14 and E-15. Experience from other reservoir projects in New England has shown that only minimal amounts of sedimentation can be expected to take place.

34. FUTURE STUDIES

Post flood studies will be made of each period of reservoir regulation to determine efficiency of the communications and reporting networks, the applicability of regulation guides including stage-discharge relationships, discharge correlations and flood reductions at damage centers.

As previously mentioned, low flow studies are presently underway to determine the feasibility of utilizing portions of the flood control pool at Otter Brook for water quality releases downstream on the Ashuelot River. Further observations must also be made to determine low flow times of travel for critical reaches below Otter Brook Lake.

In conjunction with this study, the possibility of using computer and radio equipment to control all gate operations during low flow periods is also being studied. This program could be accomplished with little new expenditures of money. The necessary computer and radio network are already integrated into the NED system. The only new equipment required would be the software for the computer and the actual gate controlling equipment at the dam.

CHAPTER VI

MANAGEMENT

35. GENERAL

a. Project Owner. Both Surry Mountain and Otter Brook Lakes are owned by the Department of the Army, Corps of Engineers.

b. Operating Agency. Department of the Army, Corps of Engineers, New England Division, is responsible for the operation of both projects. These projects are staffed on a normal work week from 0800 to 1630, Monday through Friday and 0800 to 0900 on Saturday with the head operator living at the site on constant call. During flood emergency conditions, the projects would be staffed on a 24 hour basis for the duration of the emergency condition.

Recreation facilities at Otter Brook Lake are operated by the State of New Hampshire, Department of Resources and Economic Development, Division of Parks, under license.

The names, addresses and phone numbers of the dam operators and basin regulators can be found in the RCC telephone directory which is revised annually.

c. Regulating Agency. Department of the Army, Corps of Engineers, New England Division, Reservoir Control Center is responsible for the regulation of both projects.

36. FUNCTIONAL RESPONSIBILITIES

a. Corps of Engineers. The reservoir regulation management and operation functions of the New England Division are performed by the Reservoir Control Center (RCC), a section of the Water Control Branch. Routine operations and maintenance activities at Surry Mountain and Otter Brook are performed by the dam operators under the supervision of the Reservoir Branch of the Operations Division. During regulation periods, the dam operator is responsible to the Control Center and reports directly to the Center for information and instructions.

The RCC consists of a staff of highly trained hydrologic engineers who devote full time to the operation of reservoirs located within the New England Division. Members of the Hydrologic Engineering, Hydraulics, and Water Quality Sections of the Water Control Branch of the Engineering Division not only assist the RCC during routine and flood operations but also provide technical assistance to the Center from time to time. An organization chart for reservoir regulation in the New England Division is shown on plate E-55.

The RCC is divided into basin units, each responsible for receiving routine hydrologic and meteorologic reports and directing reservoir regulation within an assigned river basin. Personnel from RCC and the other three sections of the Water Control Branch are assigned to these units. Each unit consists of a regulator in charge of the overall operation in the basin, and project regulators who receive reports and issue instructions to individual dams either from NED headquarters during working hours or from their homes during non-working hours. Whenever emergency conditions so require, the RCC staffs NED headquarters and the regulation units are organized to assure 24 hour operation as long as the emergency exists.

b. Other Agencies. There are no other Federal, State, county or private agencies that have any responsibility in regulating either Surry Mountain or Otter Brook Lakes.

37. INTER-AGENCY COORDINATION

a. General. It is the policy of the Corps of Engineers to cooperate with the local press and all other forms of mass news media. This cooperation provides the local community with information regarding the regulation of the Ashuelot River projects.

The primary source of information regarding the regulation of the projects is the Public Affairs Officer. He is responsible for issuing all communiqués to the press and news media.

At times the head dam operators receive requests for information from local news media and private citizens. The operator can give out that information pertinent to his project. However, the operator will not make any flood forecasts. Referrals should be made to RCC for additional information.

b. Inter-Agency Agreements. The Corps of Engineers has inter-agency agreements with the U.S. Geological Survey, the National Weather Service and its River Forecast Center at Hartford, Connecticut. The Corps of Engineers provides these agencies with data to assist them in developing hydrologic forecasts for the Ashuelot River watershed. The Corps, in turn, uses this information to regulate its projects in a manner to provide efficient protection for downstream communities.

c. Compacts. Congress, by the passage of Public Law 52, 83d Congress, 6 June 1953, granted its consent and approval to an interstate compact covering the Connecticut River Valley that had been previously ratified by the States of New Hampshire, Vermont, Massachusetts and Connecticut. The principal purposes of the compact are:

(1) Assuring adequate storage capacity for impounding waters of the basin in the interest of flood control. Five dams, Union Village, Surry Mountain, Knightville, Tully and Birch Hill were in operation at the time the compact was instituted. These dams were endorsed by the compact and included in the tax sharing clause. Twelve additional locations were agreed upon for construction by the United States.

(2) A system of tax loss reimbursement was set up so that the Southern Connecticut River Basin States would share the tax loss with the Northern States from Federal acquisition of lands for any flood control dam and reservoir built in the Connecticut River Valley. A tabulation of this tax reimbursement is listed below:

Recipient State	Percent Tax Loss Reimbursed	Reimbursing State
Vermont	40	Connecticut
Vermont	50	Massachusetts
New Hampshire	40	Connecticut
New Hampshire	50	Massachusetts
Massachusetts	40	Connecticut

(3) Providing a joint or common agency through which the signatory states may effectively cooperate in accomplishing the objectives of flood control and water resources utilization in the basin.

The compact also provides for creation of a commission consisting of three representatives from each of the four states with authority to enter into contracts and agreements and to make such ongoing studies and investigations as may be required in the interest of flood control and in cooperation with Federal agencies.

d. Conservation Regulation. The only regulation for conservation at both Surry Mountain and Otter Brook Lakes is the release made for downstream fish life. A minimum release rate of 10 cfs must be maintained from both projects during periods of regulation.

CHAPTER VII

OPERATIONAL PROCEDURES AND MAINTENANCE OF HYDROLOGIC EQUIPMENT

38. PRECIPITATION GAGE

A standard weighing and recording NWS precipitation gage has been installed at both Surry Mountain and Otter Brook Lakes. These gages serve as supplement to the NWS rainfall station at Keene, New Hampshire.

39. RESERVOIR STAGE RECORDER

The automatic float-operated water level recorders at Surry Mountain and Otter Brook trace the water level in the reservoirs at all times. The recording instruments should be checked each morning to assure that the clock is keeping correct time and the pen is tracing properly. Any discrepancies in the record as evidenced by the pen time or gage height should be noted on the chart, and the instrument should be reset. During periods of reservoir storage, the outside tile or staff gage should be read to check tape readings and chart records. Should the recorder become inoperable, RCC should be notified and arrangements will be made to repair the instrument.

The chart record should be changed the first working day of each month at Otter Brook and each week at Surry Mountain, and the following information should be noted in ink at the beginning and end of each chart:

Outside (tile) gage reading
Pen gage height reading
Watch time
Pen time
Date and name of dam

New charts for weekly and monthly recorders should be obtained from the NED warehouse.

40. TAILWATER GAGING STATION

USGS gaging stations are located downstream of Surry Mountain and Otter Brook. These stations provide a continuous official record of releases from the dams. They are equipped with digital-type water stage recorders and are operated and maintained under a cooperative stream gaging program. In addition to the gage at Surry Mountain, a remote transmitter is located at the gage and a remote receiver recorder in the gate house. it is essentail that the gages be checked frequently to assure proper operation. If inspection indicates a need for repair, RCC should be notified immediately and arrangements will be made with the USGS to have the equipment repaired.

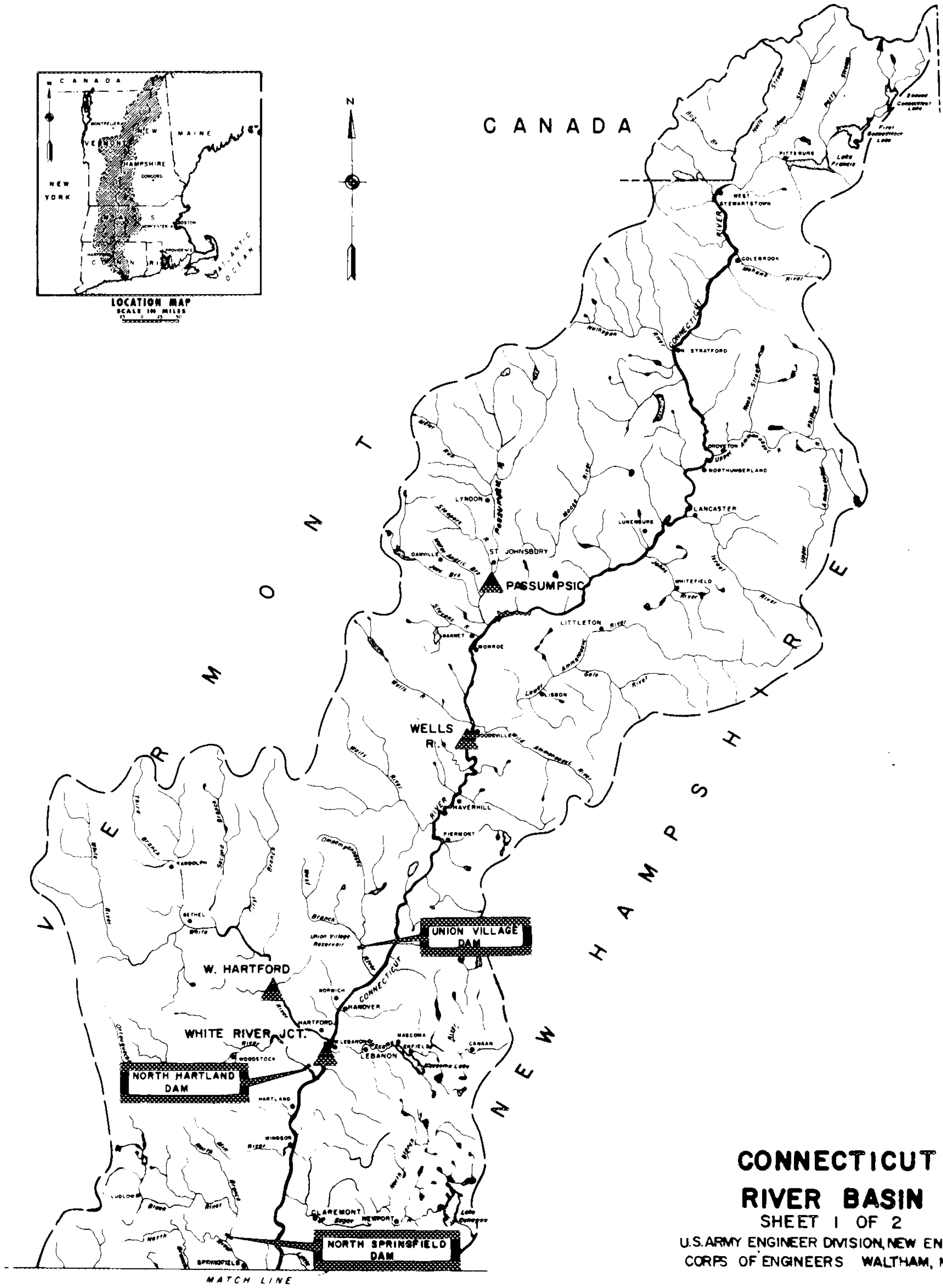
41. TELEPHONE TRANSMITTER (TELEMARK)

Two telephone transmitters are used for regulation in the Ashuelot River watershed, one on the Ashuelot River in Keene and another on the Connecticut River at Montague City. The head operator at Surry Mountain is the primary calling agent for the Keene telemark. It is his responsibility to check the gage on a weekly basis. The Otter Brook head operator and the assistants from both projects should familiarize themselves with the operation of the Keene telemark. The head operator of Birch Hill Dam is the primary calling agent for the Montague City gage, however, the head operators or assistants at both Surry Mountain and Otter Brook should call the gage at least once each month to familiarize themselves with its code. During failure of communications, the Ashuelot River projects must regulate for Montague City stages. Should the telemark at Montague City become inoperable during the monthly check, the head operator should notify the RCC. Should the telemark at Keene become inoperative, the Surry Mountain operator should visit the gage to ascertain the source of difficulty. If the trouble cannot be determined at the gage, the telephone company should be requested to check out their circuits in the presence of the dam operator. If the telemark still is not functioning by this time, the RCC should be notified and NED or USGS personnel will inspect the gaging station.

Batteries for the ADR-BDT equipment at the Montague City gage will be furnished and installed by the USGS.

42. SNOW SAMPLING SET

A snow sampling set has been assigned to each of the head operators. Procedures for obtaining snow survey data should follow instructions set forth in "Snow Sampling Guide, Department of Agriculture, Handbook 1960." If given proper care, the only maintenance required would be occasional replacement of wornout cutterheads.



CONNECTICUT RIVER BASIN

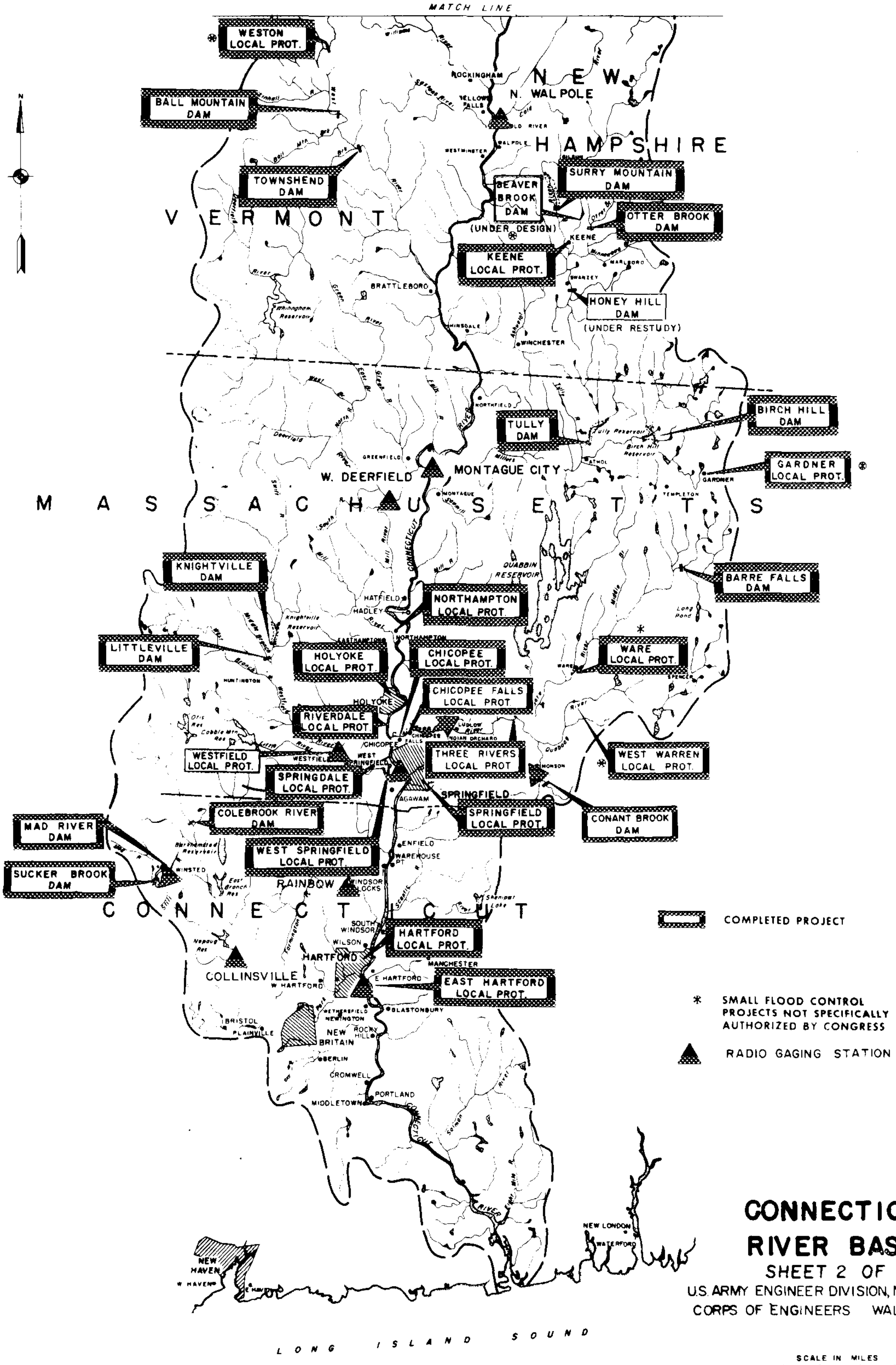
SHEET 1 OF 2

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS WALTHAM, MASS.

SCALE IN MILES

DECEMBER 1971

PLATE E-1



CONNECTICUT RIVER BASIN

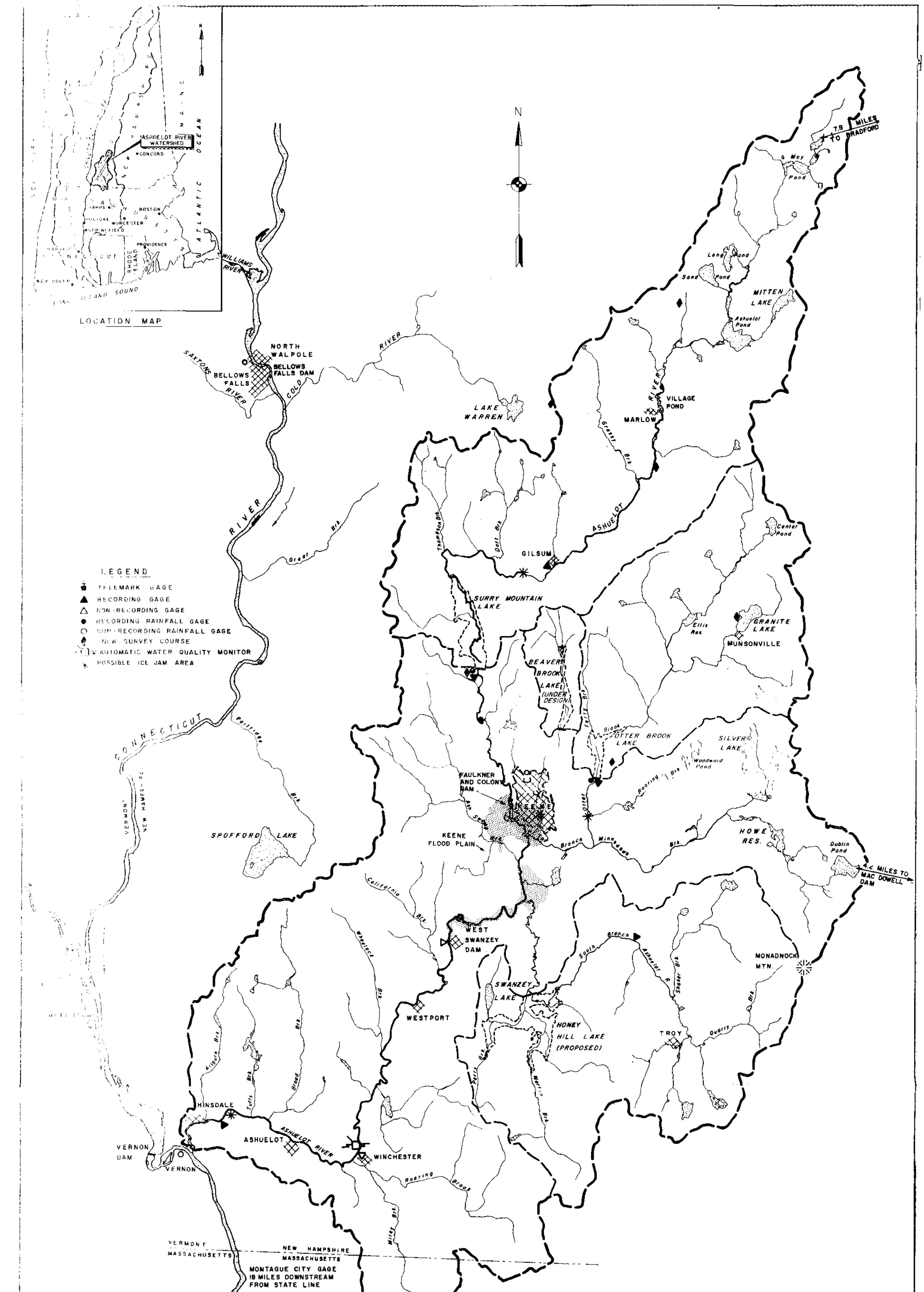
SHEET 2 OF 2

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS WALTHAM, MASS.

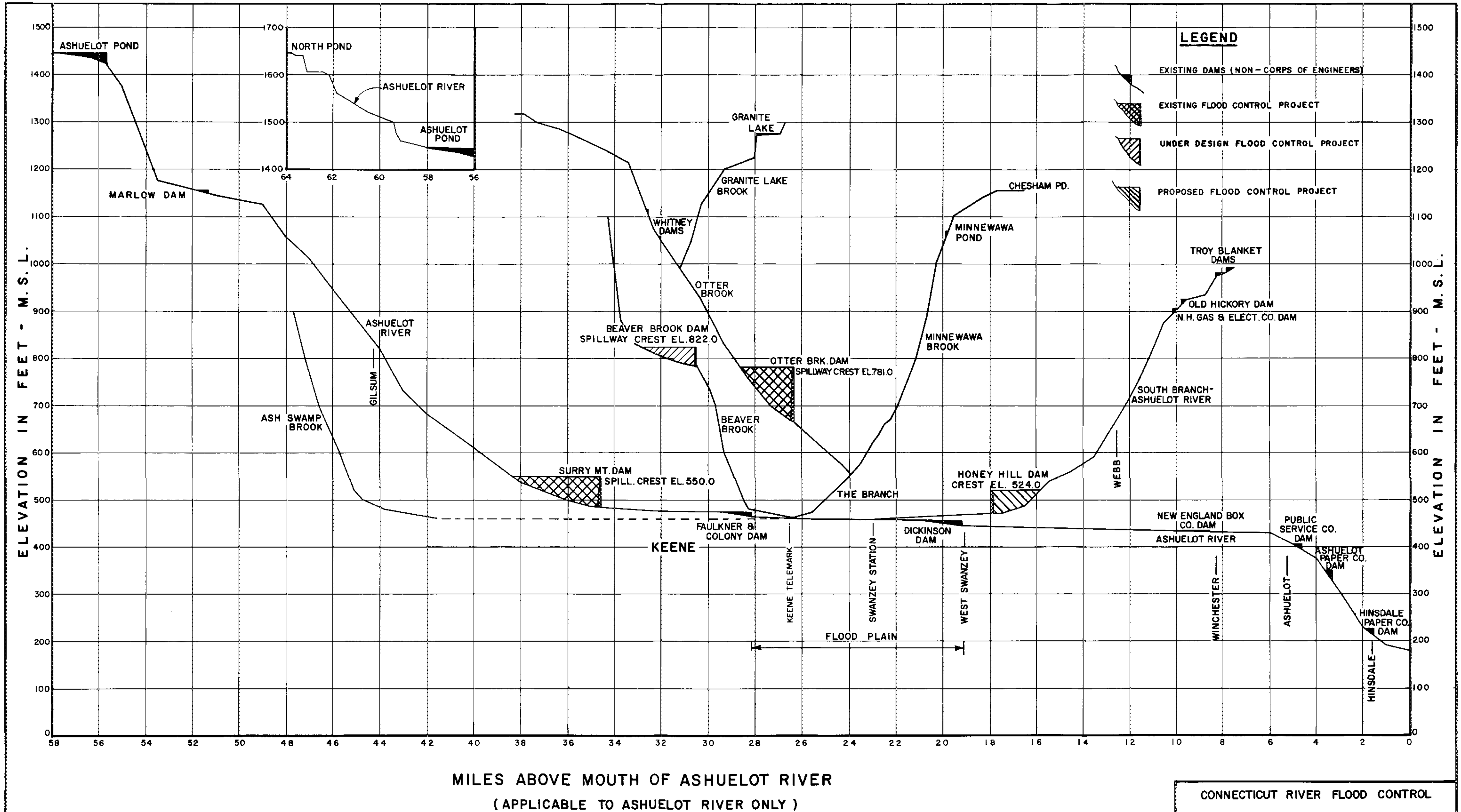
SCALE IN MILES

DECEMBER 1971

PLATE E-2



CONNECTICUT RIVER FLOOD CONTROL
ASHUELOT RIVER
WATERSHED MAP
DEPARTMENT OF THE ARMY - NEW ENGLAND DIVISION
CORPS OF ENGINEERS - WALTHAM, MASS.
NOVEMBER 1971



CONNECTICUT RIVER FLOOD CONTROL

ASHUELOT RIVER BASIN PROFILES

ASHUELOT RIVER AND TRIBUTARIES

NEW ENGLAND DIVISION WALTHAM, MASS.
JUNE 1965

PLATE E-4

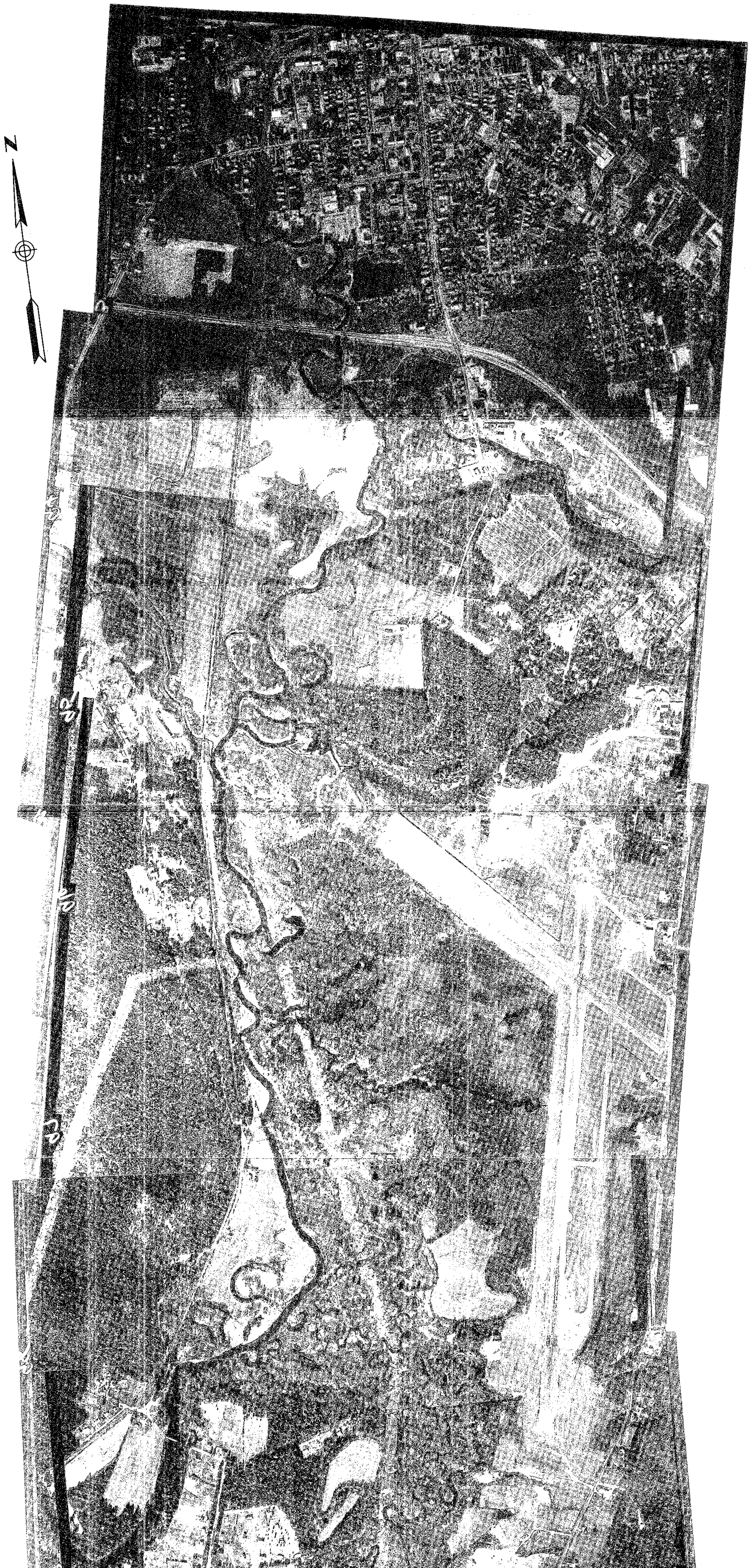


PLATE E-5

KEENE N.H. FLOOD PLAIN

PHOTO FLOWN NOV. 1971

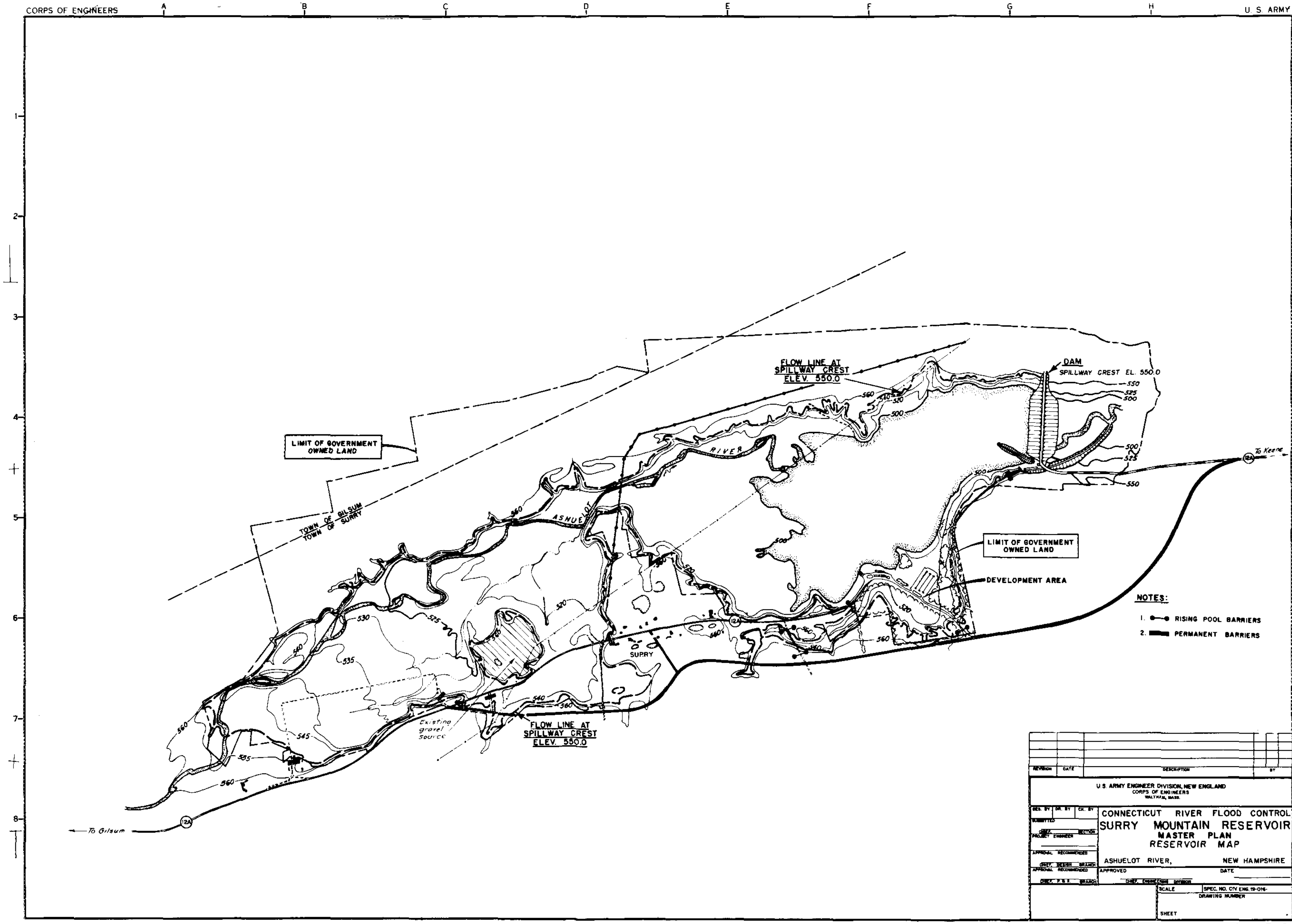
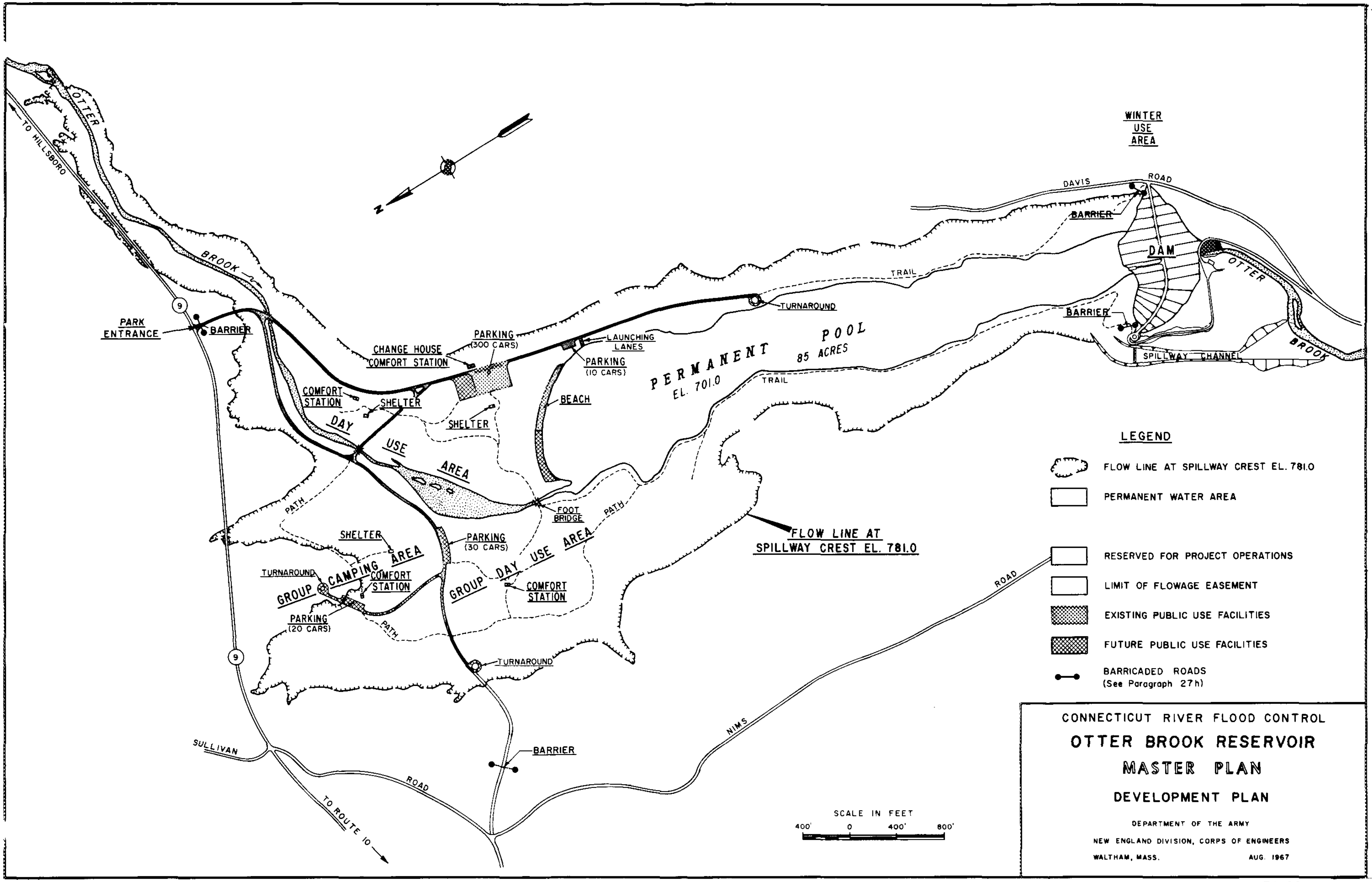
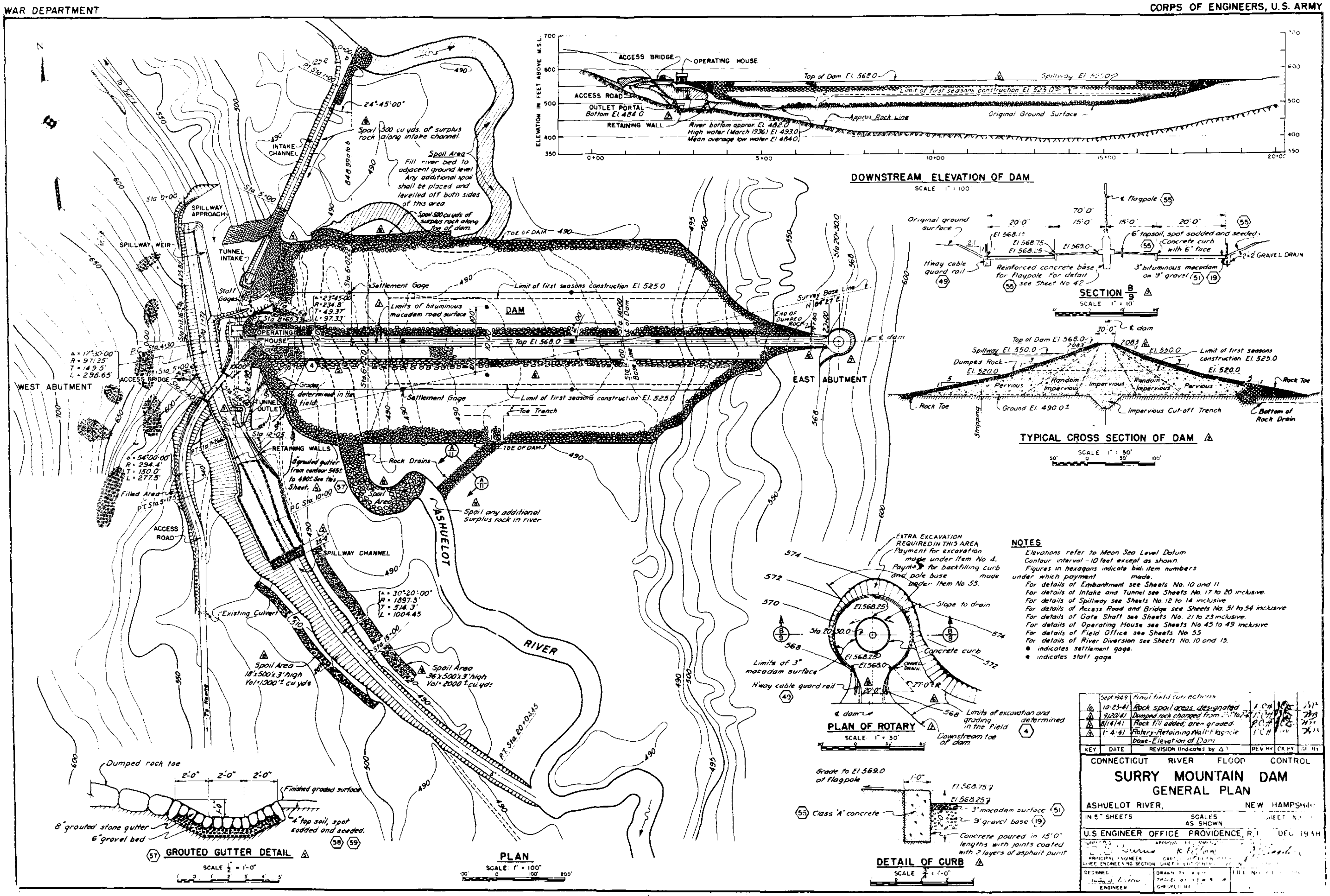

CORPS OF ENGINEERS
U.S. ARMY
LIMIT OF GOVERNMENT OWNED LAND
TOWN OF GILSUM
TOWN OF SURRY
FLOW LINE AT SPILLWAY CREST ELEV. 550.0
DAM
SPILLWAY CREST EL. 550.0
ASHUELOT
RIVER
To Keene
DEVELOPMENT AREA
NOTES:
1. RISING POOL BARRIERS
2. PERMANENT BARRIERS
SURRY
Existing gravel source
To Gilsum
12A
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
CONNECTICUT RIVER FLOOD CONTROL
SURRY MOUNTAIN RESERVOIR
MASTER PLAN
RESERVOIR MAP
ASHUELOT RIVER, NEW HAMPSHIRE
APPROVED
DATE
SCALE
SPEC. NO. CIV ENG. 19-016-
DRAWING NUMBER
SHEET

PLATE E-6



N
TO HILLSBORO
OTTER
BROOK
9
PARK ENTRANCE
BARRIER
CHANGE HOUSE
COMFORT STATION
PARKING
(300 CARS)
COMFORT STATION
SHELTER
SHELTER
DAY USE AREA
LAUNCHING LANES
PARKING
(10 CARS)
BEACH
TURNAROUND
PERMANENT POOL
EL. 701.0
85 ACRES
TRAIL
TRAIL
WINTER USE AREA
DAVIS ROAD
BARRIER
DAM
BARRIER
SPILLWAY CHANNEL
OTTER BROOK
PATH
FOOT BRIDGE
PATH
SHELTER
PARKING
(30 CARS)
GROUP CAMPING AREA
TURNAROUND
COMFORT STATION
GROUP DAY USE AREA
COMFORT STATION
PARKING
(20 CARS)
PATH
FLOW LINE AT SPILLWAY CREST EL. 781.0
TURNAROUND
9
BARRIER
SULLIVAN ROAD
TO ROUTE 10
NIMS ROAD
LEGEND
FLOW LINE AT SPILLWAY CREST EL. 781.0
PERMANENT WATER AREA
RESERVED FOR PROJECT OPERATIONS
LIMIT OF FLOWAGE EASEMENT
EXISTING PUBLIC USE FACILITIES
FUTURE PUBLIC USE FACILITIES
BARRICADED ROADS
(See Paragraph 27h)
SCALE IN FEET
400' 0 400' 800'
CONNECTICUT RIVER FLOOD CONTROL
OTTER BROOK RESERVOIR
MASTER PLAN
DEVELOPMENT PLAN
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.
AUG. 1967

PLATE E-7


DOWNSTREAM ELEVATION OF DAM
SCALE 1" = 100'
ACCESS BRIDGE
OPERATING HOUSE
ACCESS ROAD
OUTLET PORTAL Bottom El. 484.0
RETAINING WALL
Top of Dam El. 568.0
Spillway El. 550.0
Limit of first seasons construction El. 525.0
Approx. Rock Line
Original Ground Surface
River bottom approx. El. 482.0
High water (March 1936) El. 493.0
Mean average low water El. 484.0
ELEVATION IN FEET ABOVE M.S.L.
SECTION 8/9
SCALE 1" = 10'
℄ Flagpole
Original ground surface
H'way cable guard rail
Reinforced concrete base for Flagpole. For detail see Sheet No. 42
6" topsoil, spot sodded and seeded
Concrete curb with 6" face
2 x 2 GRAVEL DRAIN
3" bituminous macadam on 9" gravel
TYPICAL CROSS SECTION OF DAM
SCALE 1" = 50'
Top of Dam El. 568.0
Spillway El. 550.0
Dumped Rock El. 520.0
Limit of first seasons construction El. 525.0
Random Impervious
Impervious
Pervious
Rock Toe
Ground El. 490.0 ±
Impervious Cut-off Trench
Bottom of Rock Drain
DAM
Top El. 568.0
EAST ABUTMENT
WEST ABUTMENT
SPILLWAY APPROACH
SPILLWAY WEIR
TUNNEL INTAKE
INTAKE CHANNEL
TUNNEL OUTLET
RETAINING WALLS
ACCESS BRIDGE
ACCESS ROAD
SPILLWAY CHANNEL
ASHUELOT RIVER
Settlement Gage
Limits of bituminous macadam road surface
Limit of first seasons construction El. 525.0
Toe Trench
TOE OF DAM
Rock Drains
Spoil Area
Spoil any additional surplus rock in river
Survey Base Line N 84°27' E
Spoil 300 cu yds of surplus rock along intake channel.
Spoil Area. Fill river bed to adjacent ground level. Any additional spoil shall be placed and levelled off both sides of this area.
Spoil 500 cu yds of surplus rock along toe of dam.
Existing Culvert
Spoil Area 18'x500'x3' high Vol = 1000 ± cu yds
Spoil Area 36'x500'x3' high Vol = 2000 ± cu yds
Filled Area
Δ = 30°20'00" R = 1897.3' T = 514.3' L = 1004.45
Δ = 54°00'00" R = 294.4' T = 150.0' L = 277.5'
Δ = 17°30'00" R = 971.25' T = 149.5' L = 296.65'
Δ = 23°45'00" R = 234.8' T = 49.37' L = 97.33'
PLAN
SCALE: 1" = 100'
GROUTED GUTTER DETAIL
SCALE 1/2" = 1'-0"
Dumped rock toe
Finished graded surface
8" grouted stone gutter
6" gravel bed
4" top soil, spot sodded and seeded.
PLAN OF ROTARY
SCALE: 1" = 30'
EXTRA EXCAVATION REQUIRED IN THIS AREA. Payment for excavation made under Item No. 4. Payment for backfilling curb and pole base made under Item No. 55.
Slope to drain
Concrete curb
Limits of 3" macadam surface
H'way cable guard rail
Limits of excavation and grading determined in the field
Downstream toe of dam
DETAIL OF CURB
SCALE 3/4" = 1'-0"
Grade to El. 569.0 at flagpole
Class 'A' concrete
El. 568.75
El. 568.25
3" macadam surface
9" gravel base
Concrete poured in 15'0" lengths with joints coated with 2 layers of asphalt paint
NOTES
Elevations refer to Mean Sea Level Datum.
Contour interval - 10 feet except as shown.
Figures in hexagons indicate bid item numbers under which payment made.
For details of Embankment see Sheets No. 10 and 11.
For details of Intake and Tunnel see Sheets No. 17 to 20 inclusive.
For details of Spillway see Sheets No. 12 to 14 inclusive.
For details of Access Road and Bridge see Sheets No. 51 to 54 inclusive.
For details of Gate Shaft see Sheets No. 21 to 23 inclusive.
For details of Operating House see Sheets No. 45 to 49 inclusive.
For details of Field Office see Sheets No. 55.
For details of River Diversion see Sheets No. 10 and 15.
● indicates settlement gage.
● indicates staff gage.
Sept 1949 Final field corrections
10-23-41 Rock spoil areas designated
9/20/41 Dumped rock changed
8/14/41 Rock fill added, area graded.
1-4-41 Rotary-Retaining Wall-Flagpole base-Elevation of Dam
KEY DATE REVISION
CONNECTICUT RIVER FLOOD CONTROL
SURRY MOUNTAIN DAM
GENERAL PLAN
ASHUELOT RIVER, NEW HAMPSHIRE
SCALES AS SHOWN
U.S. ENGINEER OFFICE PROVIDENCE, R.I.
PRINCIPAL ENGINEER
ENGINEER

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

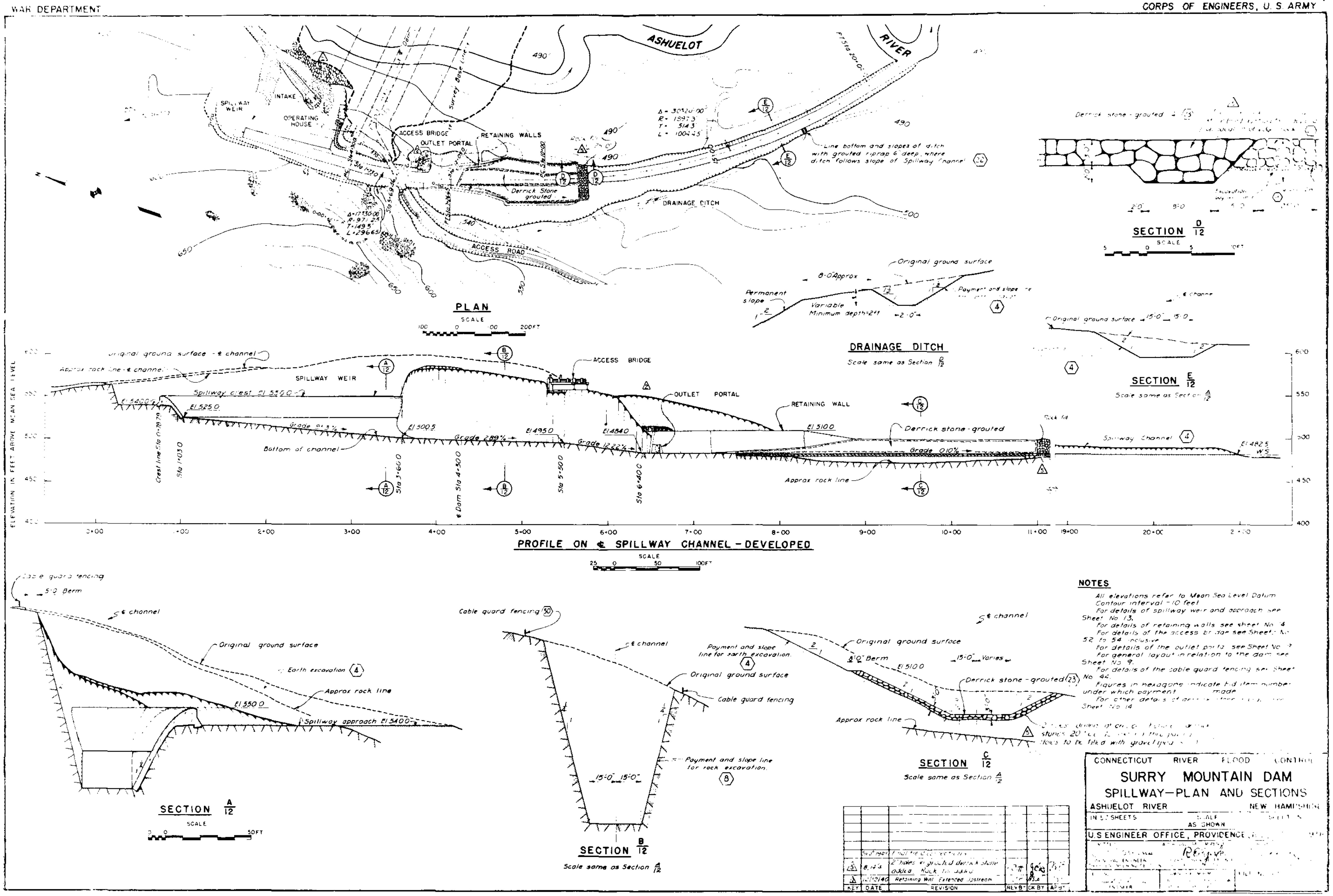
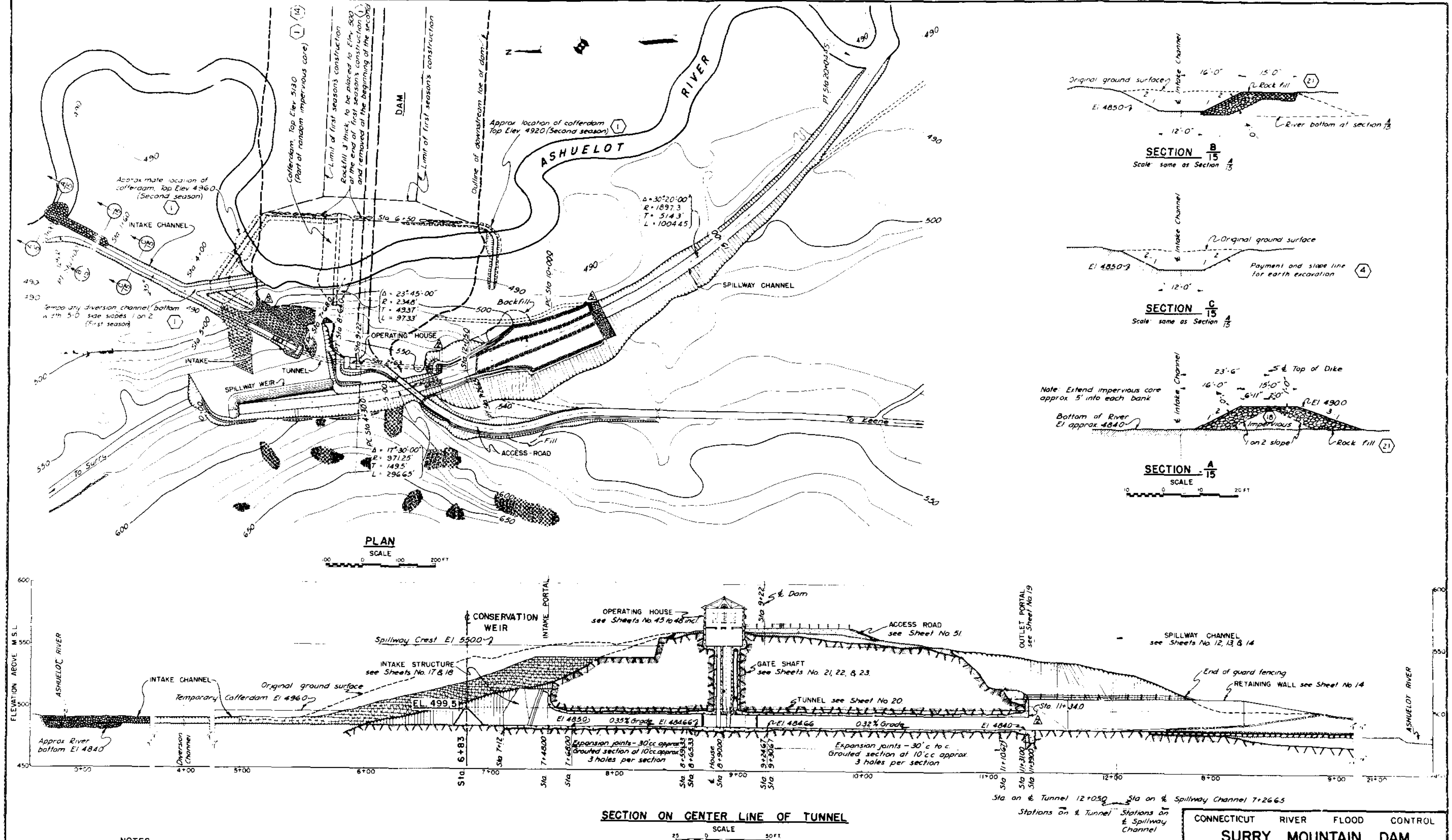


PLATE E-9



NOTES

Elevations refer to Mean Sea Level Datum
Figures in hexagons indicate bid item numbers under which payment made

Revised to show conservation weir
January 1972

KEY	DATE	REVISION	REV BY	CK BY	AP BY
	Sept 1949	Final field corrections			
A	8/14/41	Rock fill added			
A	12.12.40	Outlet portal & retaining wall revised			

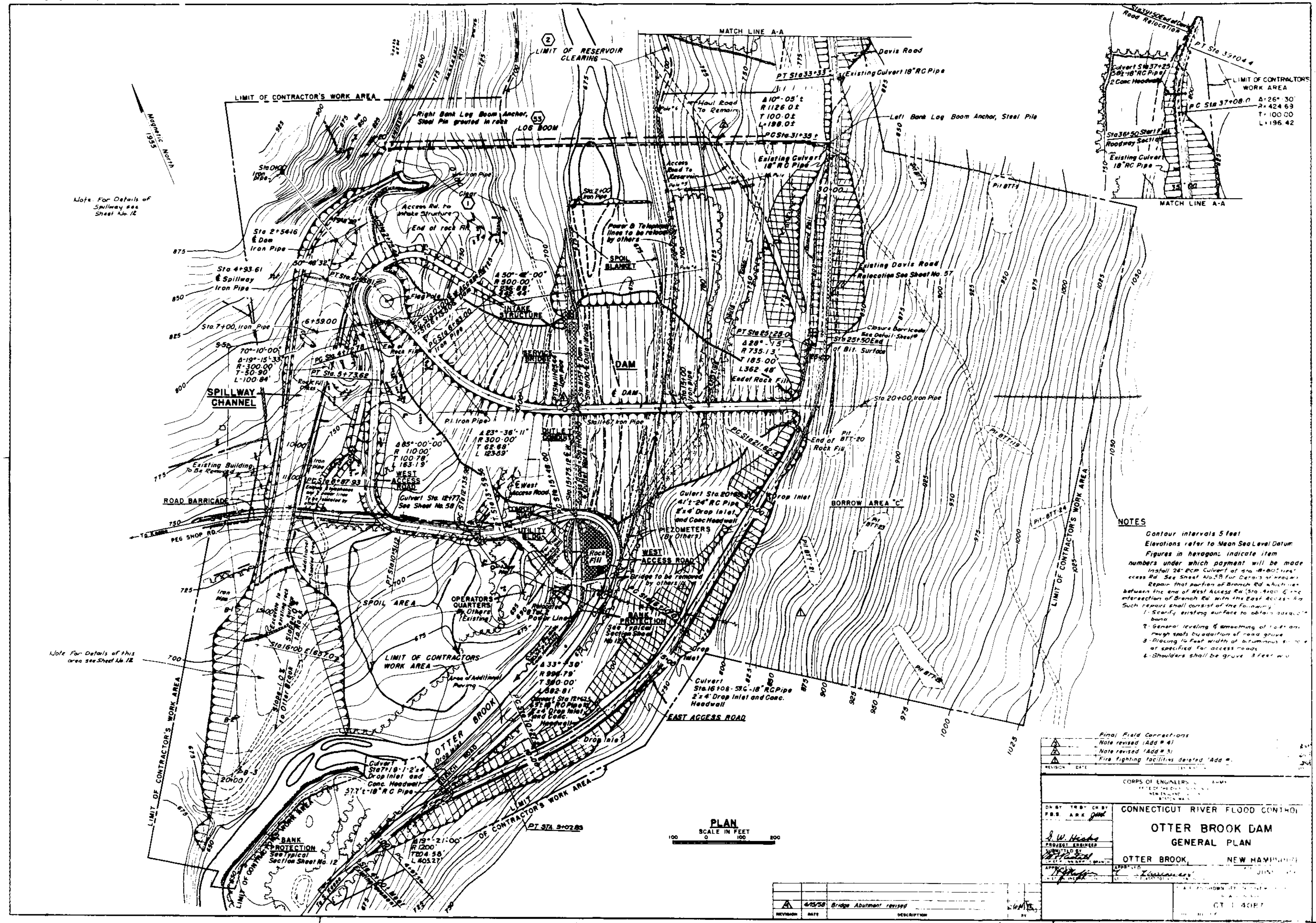
CONNECTICUT RIVER FLOOD CONTROL

SURRY MOUNTAIN DAM
OUTLET WORKS

ASHUELOT RIVER, NEW HAMPSHIRE

IN 57 SHEETS — SCALE AS SHOWN

U. S. ENGINEER OFFICE, PROVIDENCE, R.I., DEC. 1938


MATCH LINE A-A
LIMIT OF RESERVOIR CLEARING
LIMIT OF CONTRACTOR'S WORK AREA
Magnetic North 1955
LOG BOOM
Right Bank Log Boom Anchor, Steel Pipe grouted in rock
Left Bank Log Boom Anchor, Steel Pile
Davis Road
Existing Culvert 18" RC Pipe
Haul Road To Remain
Access Road To Reservoir
Note: For Details of Spillway see Sheet No. 12
Access Rd. to Intake Structure
End of rock Fill
INTAKE STRUCTURE
SPOIL BLANKET
Power & Telephone lines to be relocated by others
Existing Davis Road Relocation See Sheet No. 57
SERVICE BRIDGE
DAM
℄ DAM
SPILLWAY CHANNEL
OUTLET WORKS
Sta 20+00 Iron Pipe
End of Rock Fill
Existing Building To Be Removed
WEST ACCESS ROAD
Culvert Sta. 12+77 See Sheet No. 58
ROAD BARRICADE
PEG SHOP RD.
UTILITY BLDG.
Rock Fill
PIEZOMETERS (By Others)
WEST ACCESS ROAD
Bridge to be removed by others
BORROW AREA "C"
SPOIL AREA
OPERATORS QUARTERS By Others (Existing)
BANK PROTECTION See Typical Section Sheet No. 12
Note: For Details of this area see Sheet No. 12
LIMIT OF CONTRACTORS WORK AREA
Area of Additional Paving
OTTER BROOK
EAST ACCESS ROAD
PLAN
SCALE IN FEET
100 0 100 200
NOTES
Contour intervals 5 feet
Elevations refer to Mean Sea Level Datum
Figures in hexagons indicate item numbers under which payment will be made
Final Field Corrections
Note revised (Add # 4)
Note revised (Add # 3)
Fire fighting facilities deleted (Add #
4/15/58 Bridge Abutment revised
REVISION DATE DESCRIPTION
CORPS OF ENGINEERS
CONNECTICUT RIVER FLOOD CONTROL
OTTER BROOK DAM
GENERAL PLAN
OTTER BROOK, NEW HAMPSHIRE
PROJECT ENGINEER
SUBMITTED BY
APPROVED
CT 1 40B7

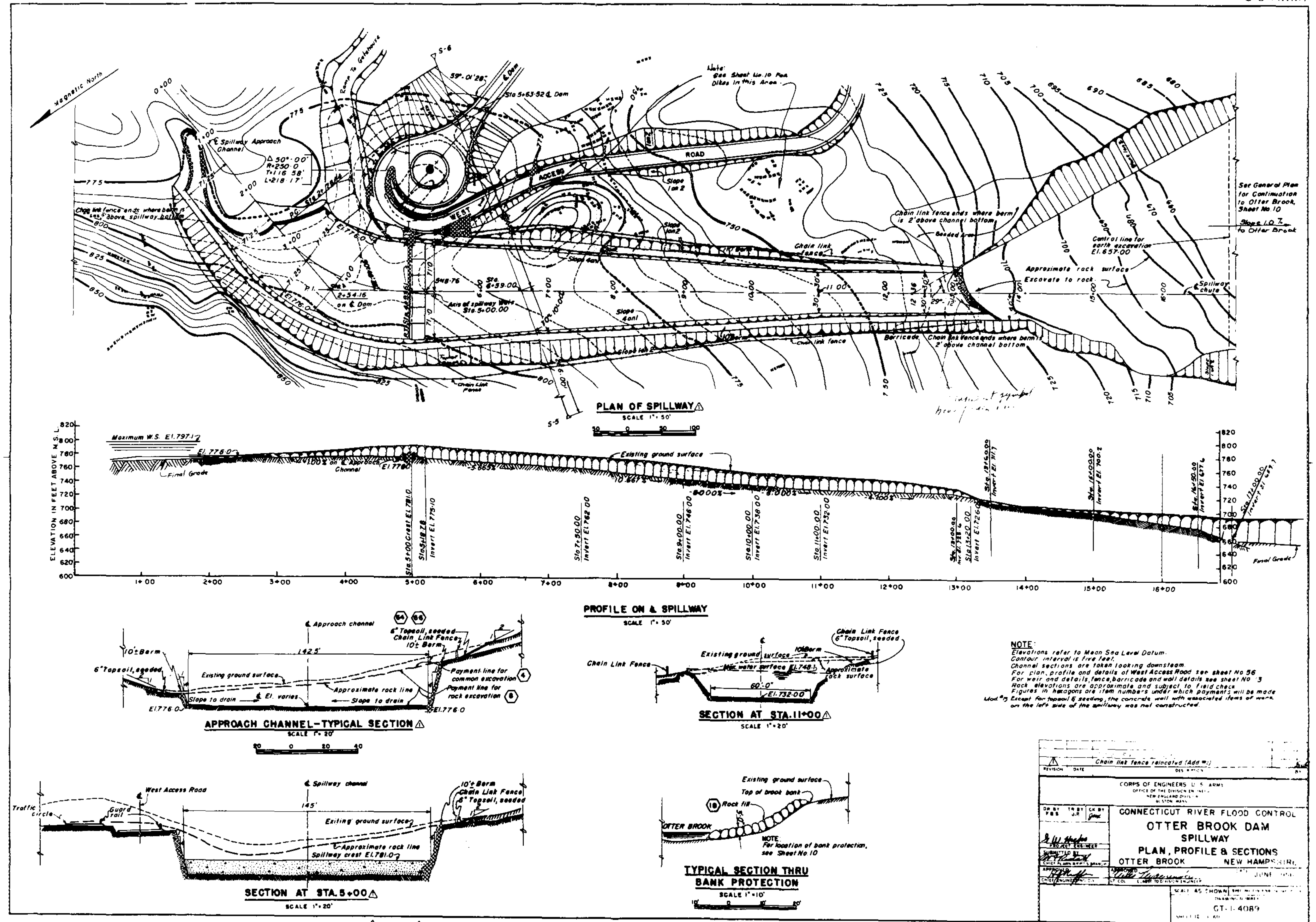
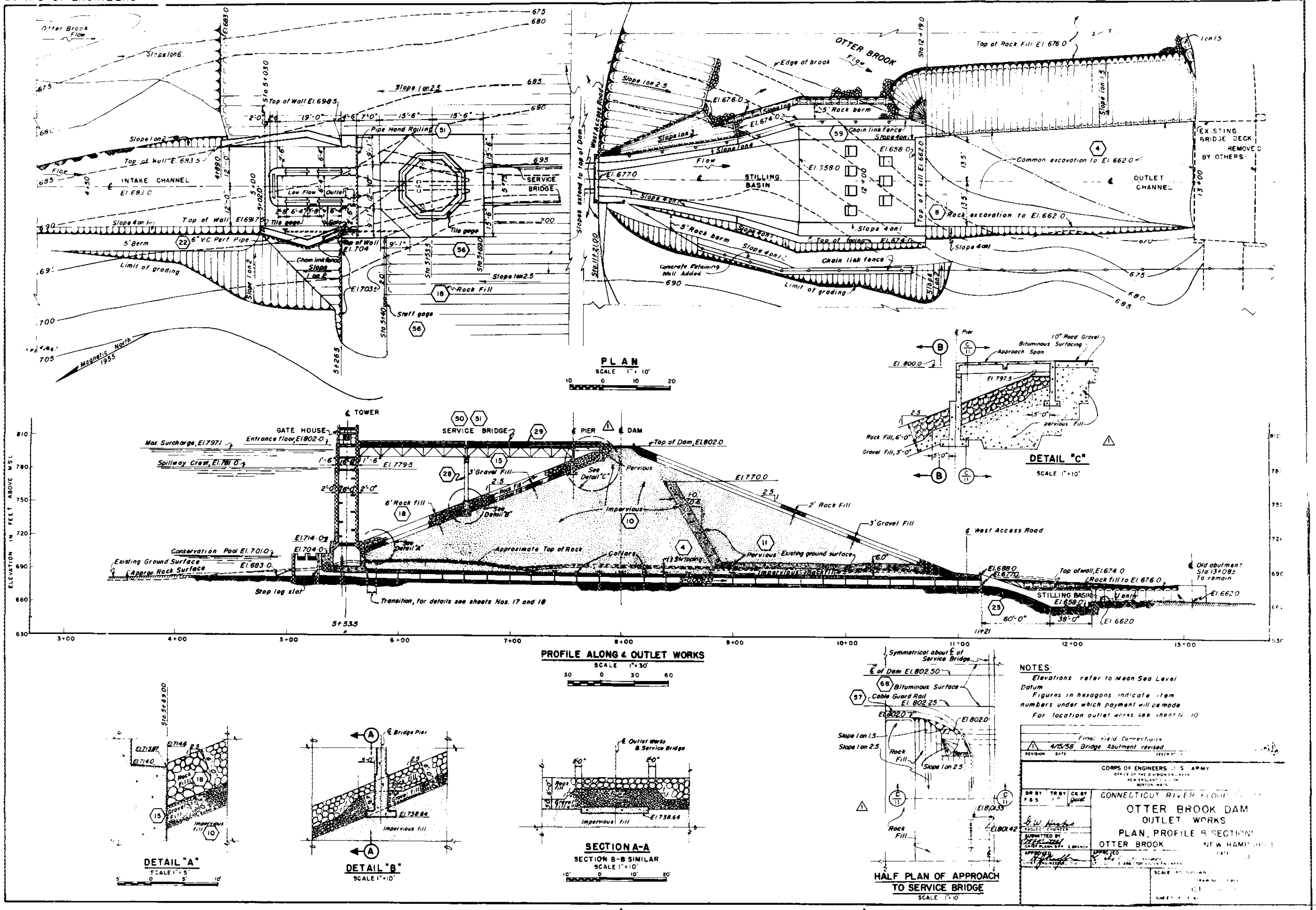
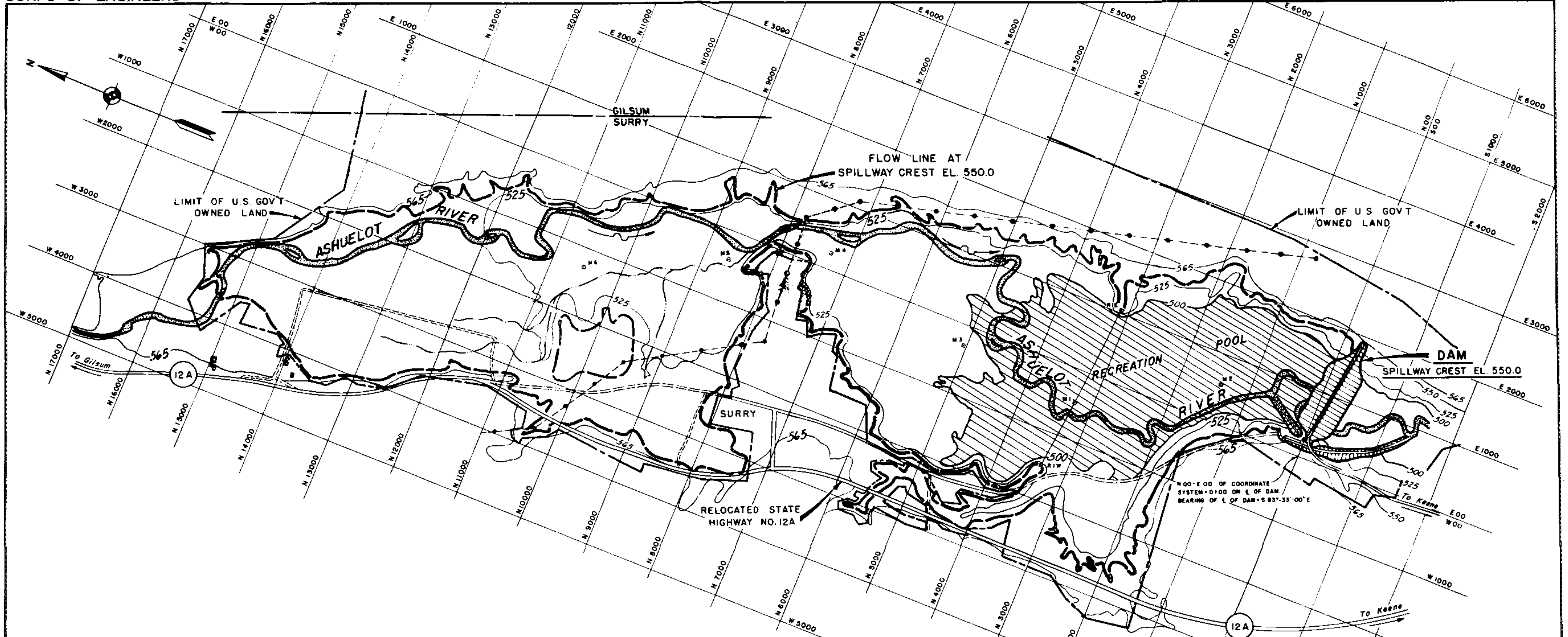

PLAN OF SPILLWAY
SCALE 1" = 50'
PROFILE ON ℄ SPILLWAY
SCALE 1" = 50'
ELEVATION IN FEET ABOVE M.S.L.
Magnetic North
Maximum W.S. El.797.1
Existing ground surface
Final Grade
APPROACH CHANNEL-TYPICAL SECTION
SCALE 1" = 20'
SECTION AT STA.11+00
SCALE 1" = 20'
SECTION AT STA.5+00
SCALE 1" = 20'
TYPICAL SECTION THRU BANK PROTECTION
SCALE 1" = 10'
NOTE:
Elevations refer to Mean Sea Level Datum.
Contour interval is five feet.
Channel sections are taken looking downstream.
For plan, profile and details of West Access Road see sheet No 56
For weir and details, fence, barricade and wall details see sheet No 3
Rock elevations are approximate and subject to field check.
Figures in hexagons are item numbers under which payments will be made
Except for topsoil & seeding, the concrete wall with associated items of work on the left side of the spillway was not constructed.
Chain link fence relocated (Add ...)
CORPS OF ENGINEERS U.S. ARMY
CONNECTICUT RIVER FLOOD CONTROL
OTTER BROOK DAM
SPILLWAY
PLAN, PROFILE & SECTIONS
OTTER BROOK NEW HAMPSHIRE
CT-1-4089

PLATE E-12


PLAN
SCALE 1" = 10'
PROFILE ALONG ℄ OUTLET WORKS
SCALE 1" = 30'
DETAIL "A"
SCALE 1" = 5'
DETAIL "B"
SCALE 1" = 10'
SECTION A-A
SECTION B-B SIMILAR
SCALE 1" = 10'
HALF PLAN OF APPROACH
TO SERVICE BRIDGE
SCALE 1" = 10'
DETAIL "C"
SCALE 1" = 10'
INTAKE CHANNEL
STILLING BASIN
OUTLET CHANNEL
OTTER BROOK
SERVICE BRIDGE
GATE HOUSE
℄ TOWER
Top of Dam, El. 802.0
Max Surcharge, El. 797.1
Spillway Crest, El. 781.0
Conservation Pool El. 701.0
Existing Ground Surface
Approx. Rock Surface
Transition, for details see sheets Nos. 17 and 18
ELEVATION IN FEET ABOVE M.S.L.
NOTES:
Elevations refer to Mean Sea Level Datum
Figures in hexagons indicate item numbers under which payment will be made
For location outlet works see sheet
4/15/58 Bridge Abutment revised
CORPS OF ENGINEERS U.S. ARMY
CONNECTICUT RIVER FLOOD CONTROL
OTTER BROOK DAM
OUTLET WORKS
PLAN, PROFILE & SECTIONS
OTTER BROOK
NEW HAMPSHIRE

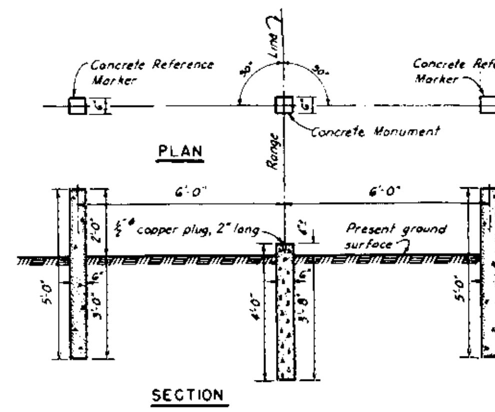


GENERAL PLAN

RANGE MONUMENTS		
MONUMENT NO.	COORDINATES	TOP EL.
R1E	N 3119.89 E 1049.87	551.11
R1W	N 3379.17 W 1494.74	551.60
M1	N 3278.46 W 476.83	495.45
M2	N 1430.93 E 542.89	493.21
M3	N 5049.46 W 295.14	502.63
M4	N 7296.46 E 255.36	511.11
M5	N 8679.96 W 408.34	513.03
M6	N 10,576.96 W 1283.54	521.72

SEDIMENTATION RECORD												
DATE OF SURVEY	REDUCTION OF AREA AT RANGES - SQ FT				DEPTH OF SEDIMENT AT MARKERS-FEET						USABLE RESERVOIR CAPACITY AC. FT	REMARKS
	R1				M1	M2	M3	M4	M5	M6		
May 1950	—				(495.0) 0.0	(492.86) 0.0	(501.86) 0.0	(510.55) 0.0	(512.31) 0.0	(521.27) 0.0	32,500	Initial Survey
Aug 1956					(495.20) +0.20	(493.04) +0.18 (1)	(502.00) +0.14	(510.67) +0.12	(512.06) -0.25	(521.22) -0.05		Monuments M3 & M6 read Nov. 1956

Note:
(1) *Not true reading - topsoil excavated from area*
(2) *Elevations in (495.0) are ground surface beside monument*



DETAILS OF RANGE MONUMENTS

SCALE ½" = 1'-0"

NOTES

Elevations refer to Mean Sea Level Datum.

Coordinates are based on dam centerline. See note on plan above.

For survey information, see Field Book No. FC-51.

For Range Profiles see Sheets Nos. CT-9-1198 & CT-9-1199.

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS. U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON MASS

DES BY W B | DR BY B G | CK BY G F D

CHIEF DESIGN BRANCH

PROJECT ENGINEER

SUBMITTED BY

CHIEF, PLANNING & REPORTS BR.

APPROVED

CHIEF ENGINEERING DIV.

CONNECTICUT RIVER FLOOD CONTROL

SURRY MOUNTAIN RESERVOIR

RESERVOIR AND SEDIMENTATION MAP

ASHUELOT RIVER NEW HAMPSHIRE

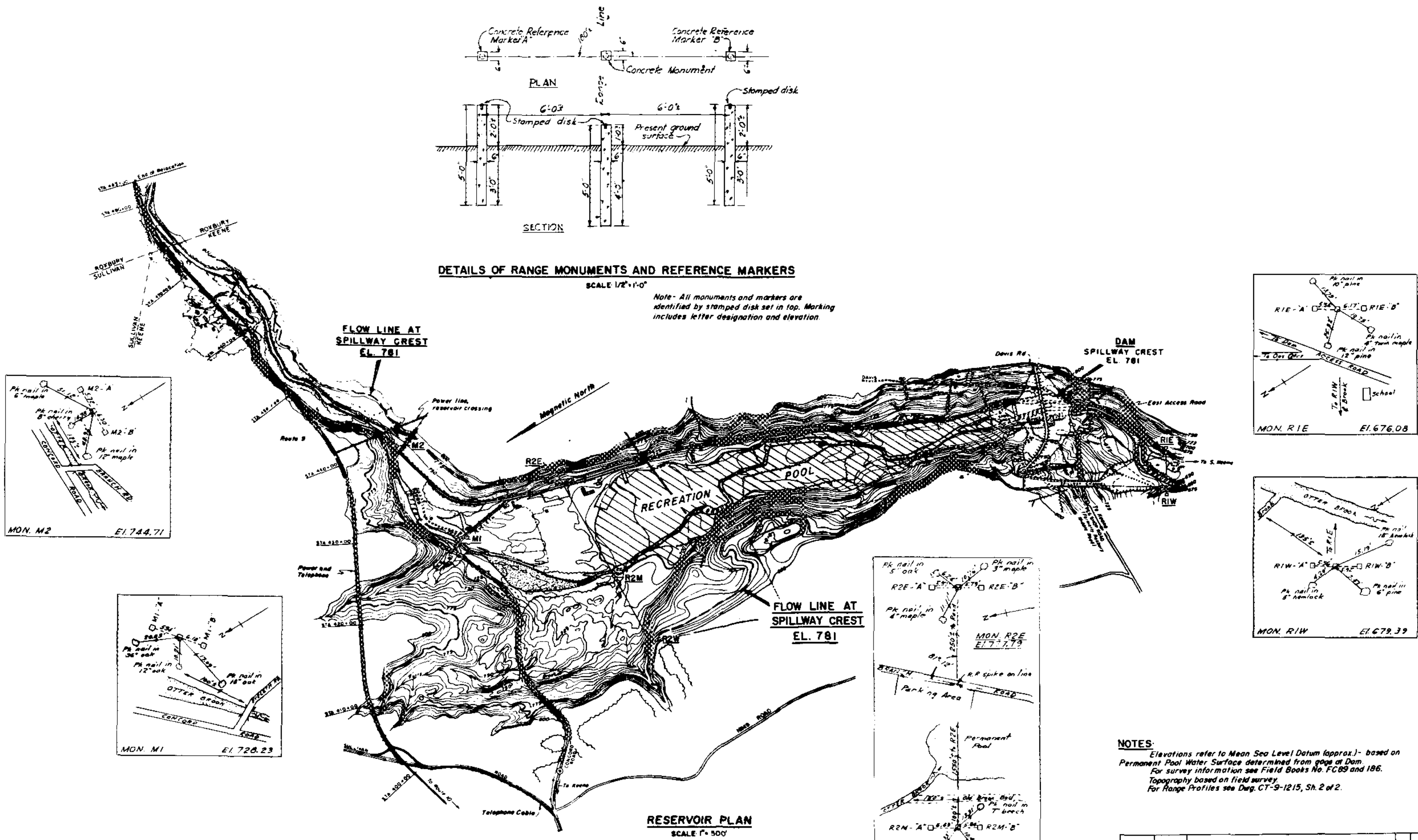
APPROVED

COL. C.E. DIVISION ENGINEER

DATE JUNE 1951

SCALE AS SHOWN | SPEC NO

DRAWING NUMBER CT-9-1193



NOTES:
Elevations refer to Mean Sea Level Datum (approx.) - based on Permanent Pool Water Surface determined from gage at Dam.
For survey information see Field Books No. FC89 and 186.
Topography based on field survey.
For Range Profiles see Dwg. CT-9-1215, Sh. 2 of 2.

SEDIMENTATION RECORD

DATE OF SURVEY	CHANGE IN AREA AT RANGES - SQ. FT. R1	R2		DEPTH OF SEDIMENT AT MARKERS — FEET R2M	M1	M2					REMARKS
JUNE 1961	—	—		(708.4) 0.0	(727.5) 0.0	(744.0) 0.0					INITIAL SURVEY USABLE RESERVOIR CAPACITY 17,600 AC. FT.

− INDICATES AGRADATION
+ INDICATES DEGRADATION

NOTE: ELEVATION IN (727.5) IS GROUND SURFACE BESIDE MONUMENT

REVISION	DATE	DESCRIPTION

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY K.B.W. | DR. BY K.H.W. | CK. BY

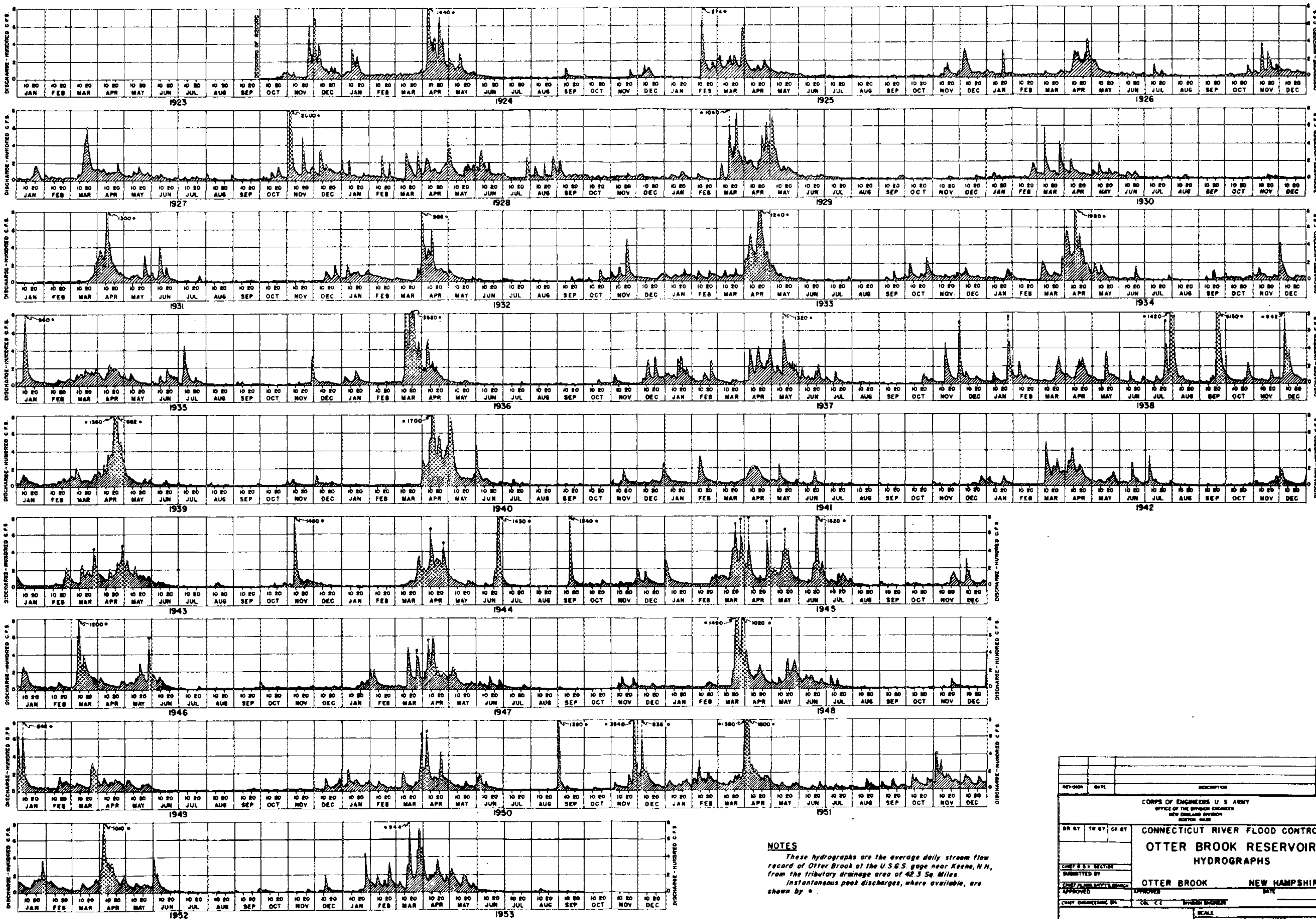
PROJECT ENGINEER

CONNECTICUT RIVER FLOOD CONTROL
OTTER BROOK RESERVOIR
RESERVOIR AND SEDIMENTATION MAP

OTTER BROOK — NEW HAMPSHIRE

APPROVAL RECOMMENDED: CHIEF, P. & R. BRANCH
APPROVED: CHIEF, ENGINEERING DIVISION
DATE AUG. 1961

SCALE: AS SHOWN | SPEC. NO. CIV. ENG. 19-016-
DRAWING NUMBER CT-9-1214



NOTES

These hydrographs are the average daily stream flow record of Otter Brook at the U.S.G.S. gage near Keene, N.H., from the tributary drainage area of 42.3 Sq. Miles.

Instantaneous peak discharges, where available, are shown by •.

CORPS OF ENGINEERS U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

CONNECTICUT RIVER FLOOD CONTROL

OTTER BROOK RESERVOIR

HYDROGRAPHS

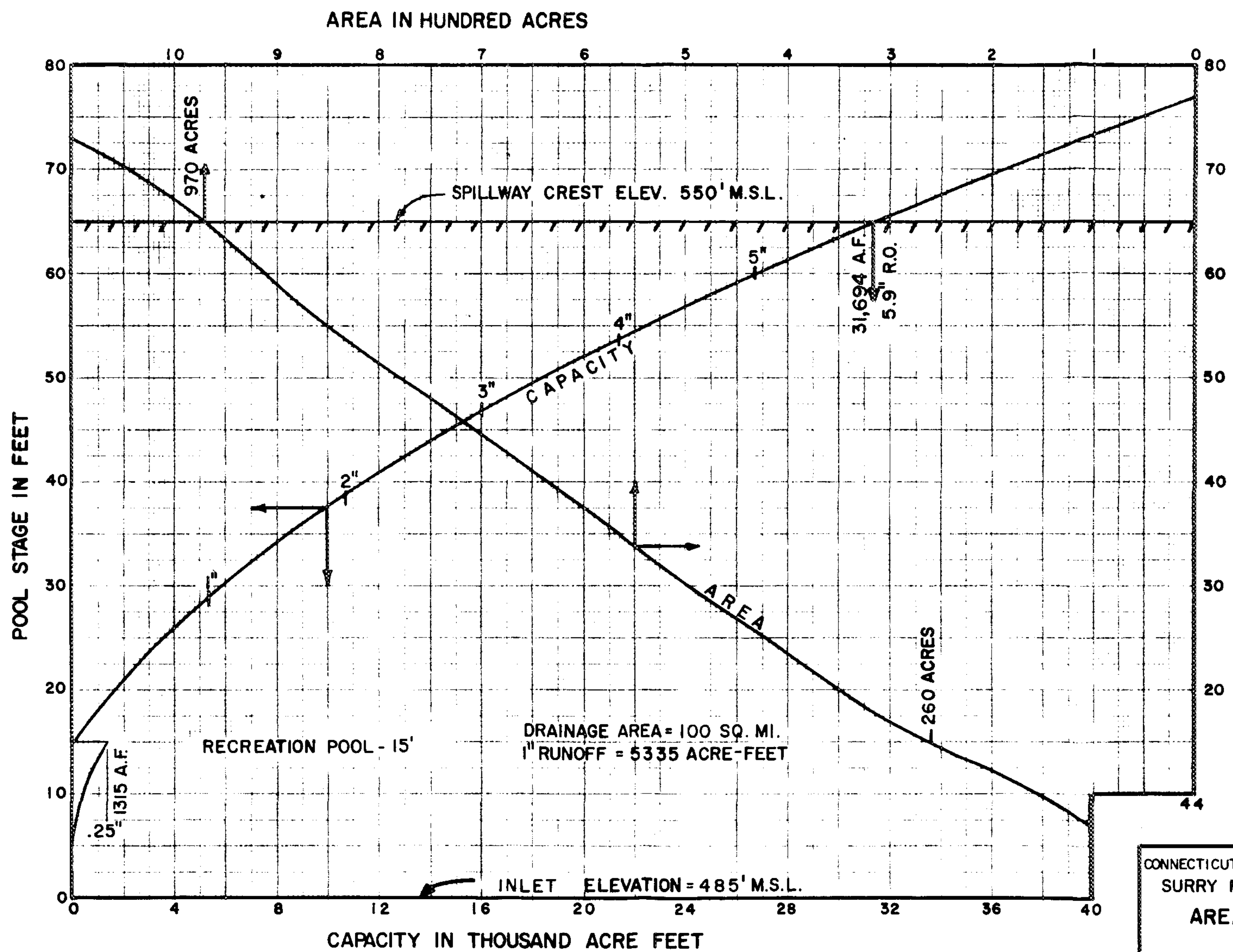
OTTER BROOK — NEW HAMPSHIRE

SURRY MT. RESERVOIR
AREA AND CAPACITY

DRAINAGE AREA = 100 S.M.

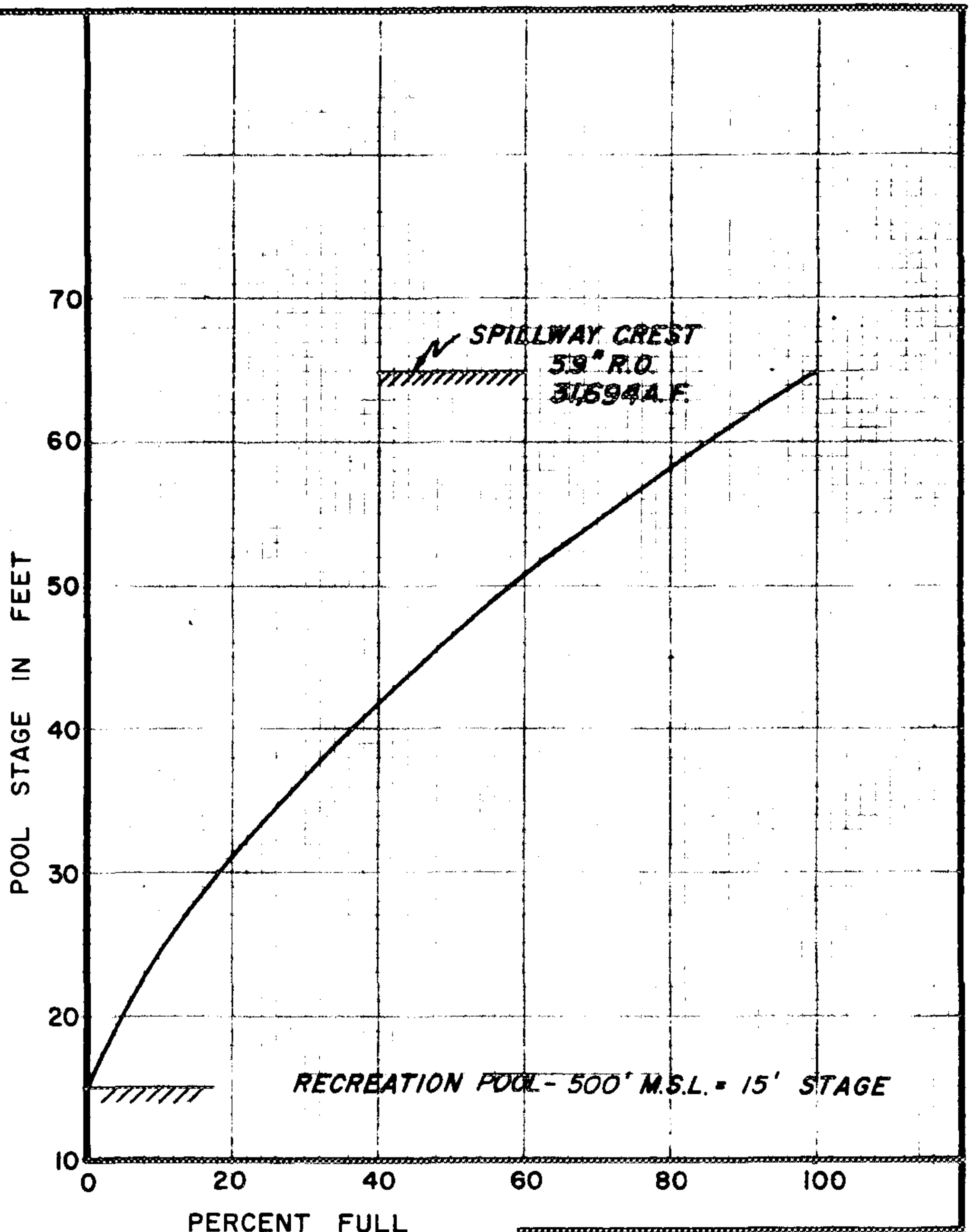
ELEV.	STAGE	AREA	CAPACITY	
M.S.L.	FEET	ACRES	AC. FT.	INCHES
485	0	0		
486	1	15	5	
487	2	30	12	
488	3	40	22	
489	4	55	32	
490	5	70	42	
491	6	85	62	.01
492	7	100	92	.02
493	8	120	132	.03
494	9	140	243	.05
495	10	155	383	.07
496	11	175	500	.09
497	12	195	700	.13
498	13	215	900	.17
499	14	240	1105	.21
499.5	14.5	250	1200	.23
500	15	260	1317	.25
RECREATION POOL - 500'				
501	16	278	269	.05
502	17	296	559	.10
503	18	314	864	.16
504	19	332	1187	.22
505	20	350	1528	.29
506	21	364	1885	.35
507	22	378	2256	.42
508	23	392	2641	.49
509	24	407	3041	.57
510	25	423	3456	.65
511	26	438	3887	.73
512	27	453	4333	.81
513	28	468	4794	.90
514	29	483	5270	.99
515	30	498	5761	1.08
516	31	512	6266	1.17
517	32	526	6785	1.27
518	33	540	7318	1.37
519	34	554	7865	1.47
520	35	567	8426	1.58

ELEV.	STAGE	AREA	CAPACITY	
M.S.L.	FEET	ACRES	AC. FT.	INCHES
521	36	580	8999	1.69
522	37	594	9586	1.80
523	38	608	10187	1.91
524	39	621	10802	2.02
525	40	635	11430	2.14
526	41	649	12072	2.26
527	42	664	12729	2.39
528	43	678	13400	2.51
529	44	693	14086	2.64
530	45	708	14786	2.77
531	46	722	15501	2.90
532	47	736	16230	3.04
533	48	750	16973	3.18
534	49	765	17731	3.32
535	50	780	18503	3.47
536	51	794	19290	3.61
537	52	808	20091	3.77
538	53	822	20906	3.92
539	54	836	21735	4.07
540	55	850	22578	4.23
541	56	862	23434	4.39
542	57	874	24302	4.55
543	58	887	25183	4.72
544	59	900	26076	4.89
545	60	913	26983	5.06
546	61	925	27902	5.23
547	62	937	28833	5.40
548	63	948	29776	5.58
549	64	959	30729	5.76
550	65	970	31694	5.94
CREST ELEVATION - 550'				
551	66	986	32672	6.12
552	67	1002	33666	6.31
553	68	1018	34676	6.50
554	69	1034	35702	6.69
555	70	1050	36744	6.89
556	71	1067	37802	7.08
557	72	1084	38878	7.29
558	73	1100	39970	7.49



CONNECTICUT RIVER FLOOD CONTROL
SURRY MOUNTAIN RESERVOIR
AREA & CAPACITY CURVES
NEW ENGLAND DIVISION WALTHAM, MASS.
FEBRUARY 1962

PLATE E-18



CONNECTICUT RIVER FLOOD CONTROL
SURRY MOUNTAIN RESERVOIR

PERCENT FULL CURVE

NEW ENGLAND DIVISION WALTHAM, MASS.
FEBRUARY 1962

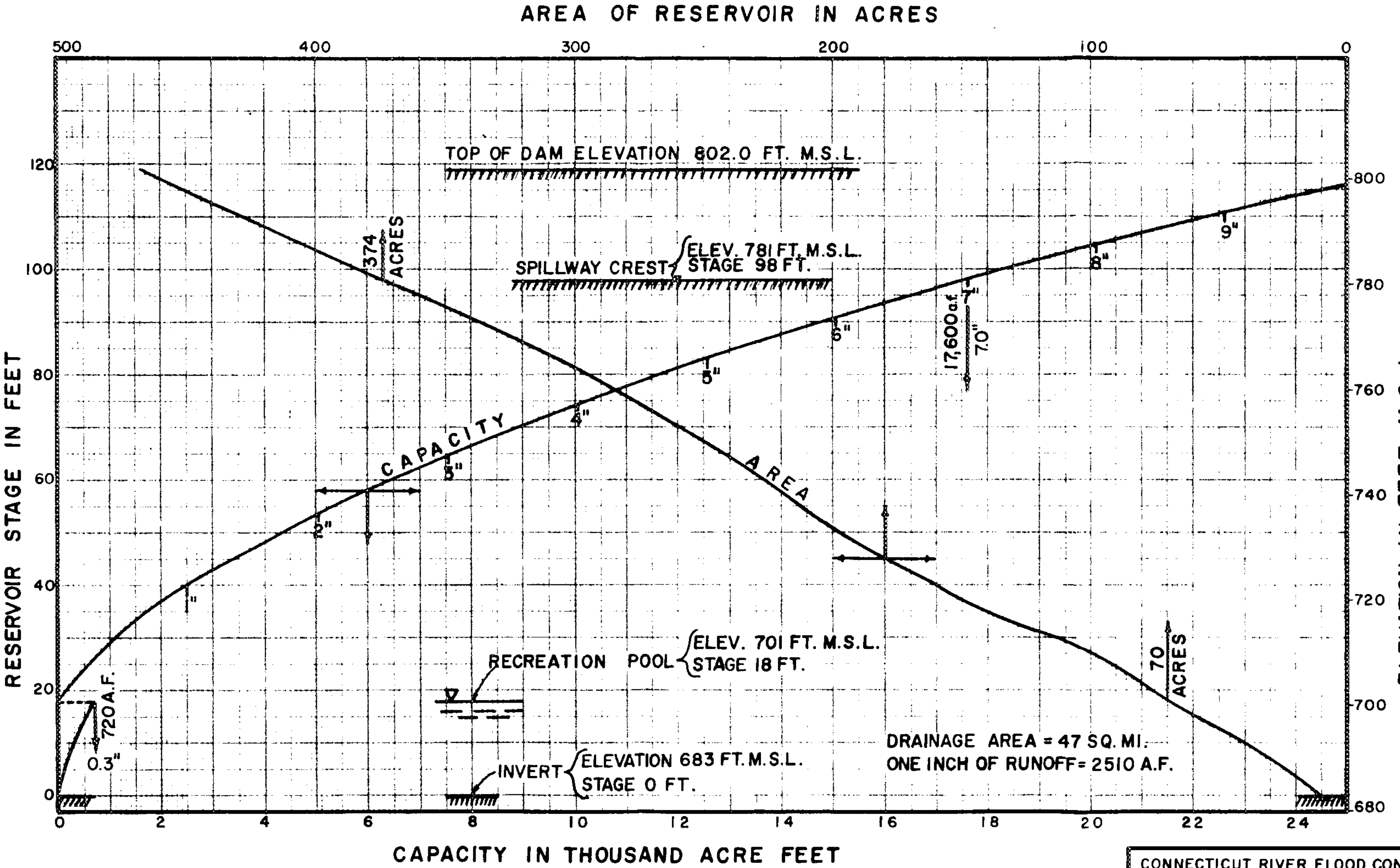
PLATE E-19

OTTER BROOK RESERVOIR
AREA AND CAPACITY

DRAINAGE AREA = 47 S.M.

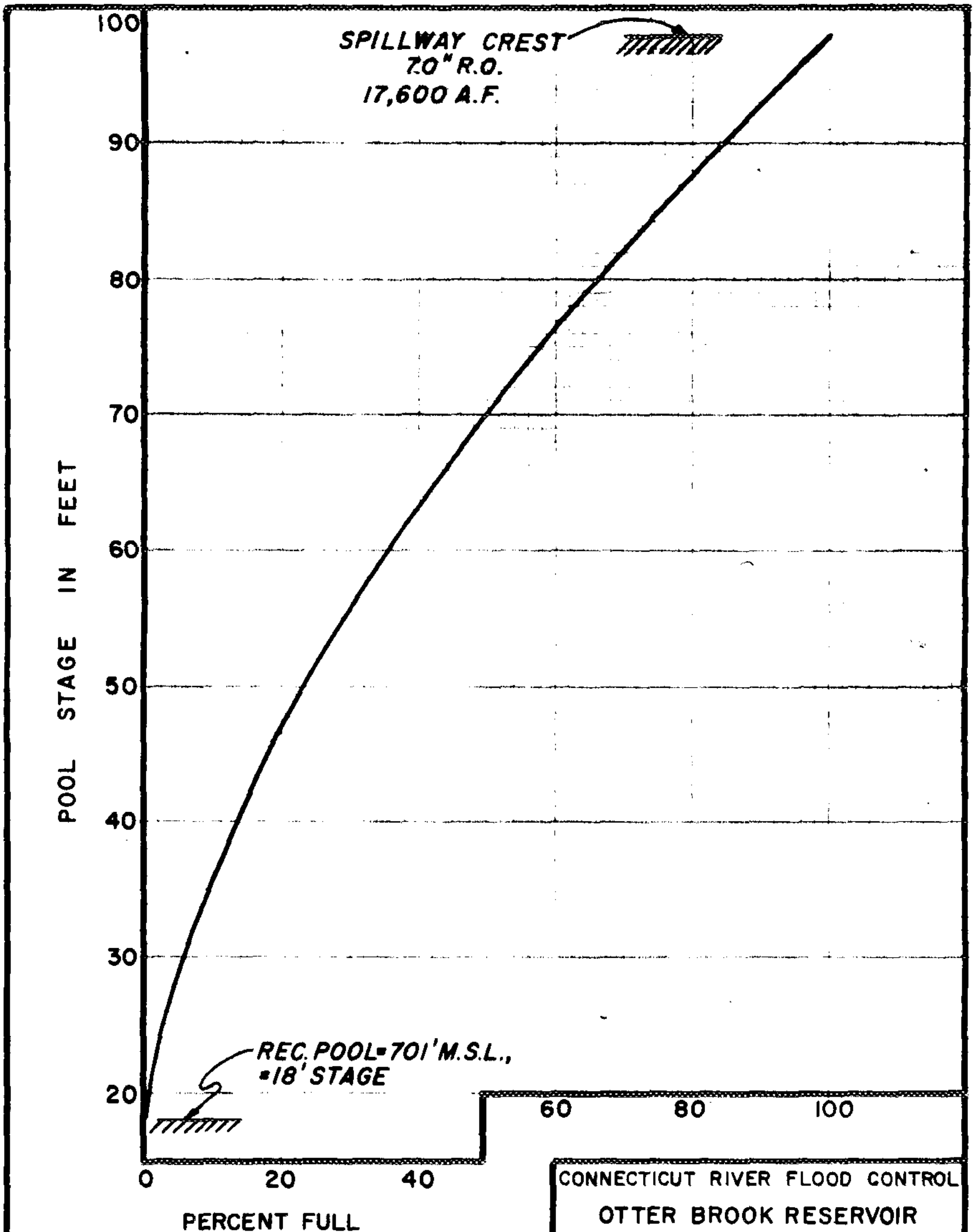
ELEV. M.S.L.	STAGE FEET	AREA ACRES	CAPACITY AC. FT.	CAPACITY INCHES
683	0	11	40	.02
685	2	16	70	.03
687	4	22	110	.04
689	6	27	160	.06
691	8	32	210	.09
693	10	40	290	.11
695	12	47	370	.15
697	14	55	480	.19
699	16	62	590	.24
701	18	70	720	.29
	Recreation Pool = 701			
701	18	70	0	0
703	20	76	150	.06
705	22	83	310	.12
707	24	90	480	.19
709	26	96	670	.26
711	28	103	870	.34
713	30	113	1080	.43
715	32	123	1320	.52
717	34	133	1580	.63
719	36	143	1850	.74
721	38	153	2150	.85
723	40	161	2460	.98
725	42	169	2790	1.11
727	44	177	3140	1.25
729	46	184	3500	1.39
731	48	192	3870	1.54
733	50	197	4260	1.70
735	52	203	4660	1.86
737	54	208	5070	2.02

ELEV. M.S.L.	STAGE FEET	AREA ACRES	CAPACITY AC. FT.	CAPACITY INCHES
739	56	214	5500	2.19
741	58	219	5930	2.36
743	60	226	6370	2.54
745	62	232	6830	2.78
747	64	239	7300	2.91
749	66	245	7790	3.10
751	68	252	8280	3.30
753	70	259	8790	3.51
755	72	266	9280	3.71
757	74	273	9880	3.93
759	76	280	10480	4.15
761	78	288	10980	4.38
763	80	296	11580	4.61
765	82	303	12180	4.85
767	84	311	12780	5.09
769	86	319	13380	5.35
771	88	327	14080	5.57
773	90	336	14680	5.87
775	92	346	15380	6.14
777	94	355	16080	6.42
779	96	365	16780	6.70
781	98	374	17600	7.00
	Crest Elevation = 781			
783	100	383	18280	7.30
785	102	392	19080	7.61
787	104	400	19880	7.93
789	106	409	20680	8.25
791	108	418	21480	8.58
793	110	427	22380	8.92
795	112	435	23180	9.26
797	114	444	24080	9.61



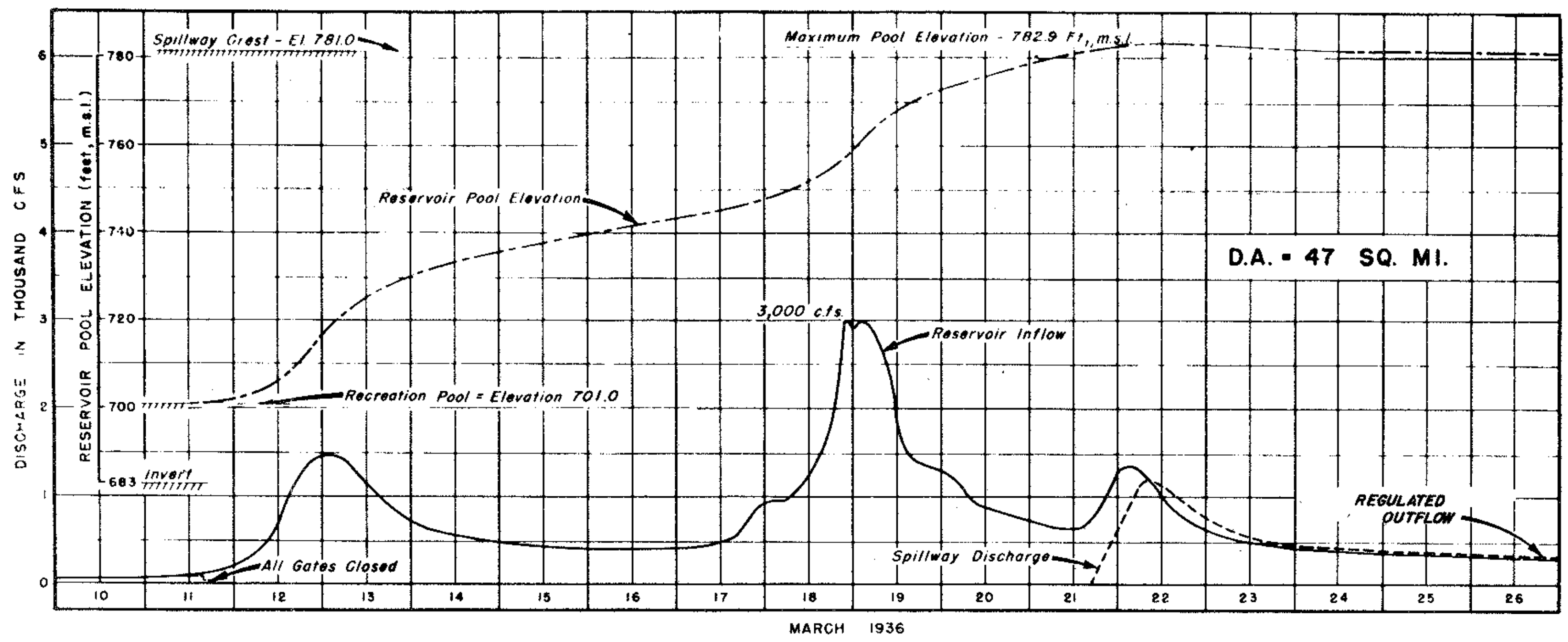
CONNECTICUT RIVER FLOOD CONTROL
OTTER BROOK RESERVOIR
AREA & CAPACITY CURVES
NEW ENGLAND DIVISION WALTHAM, MASS.
FEBRUARY 1962

PLATE E-21

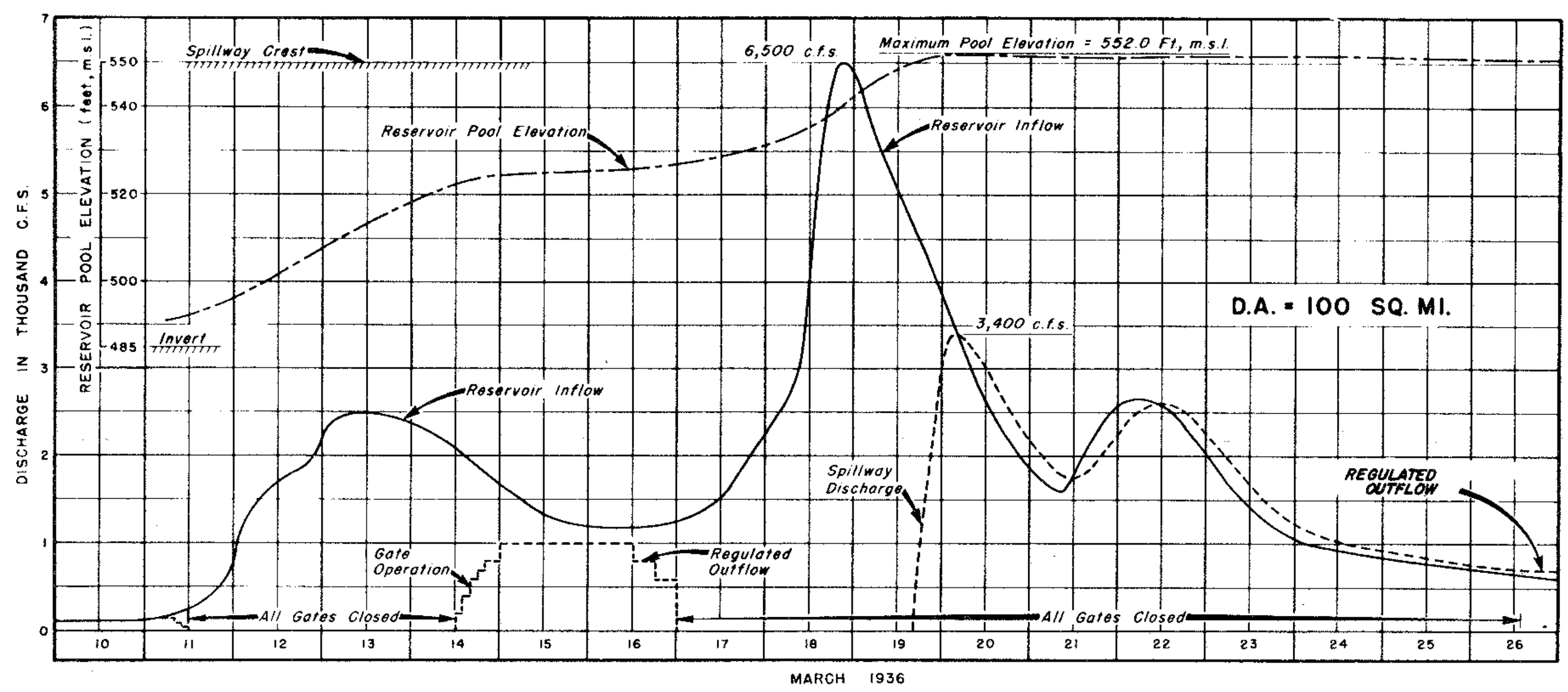


CONNECTICUT RIVER FLOOD CONTROL
OTTER BROOK RESERVOIR
PERCENT FULL CURVE
NEW ENGLAND DIVISION WALTHAM, MASS.
FEBRUARY 1962

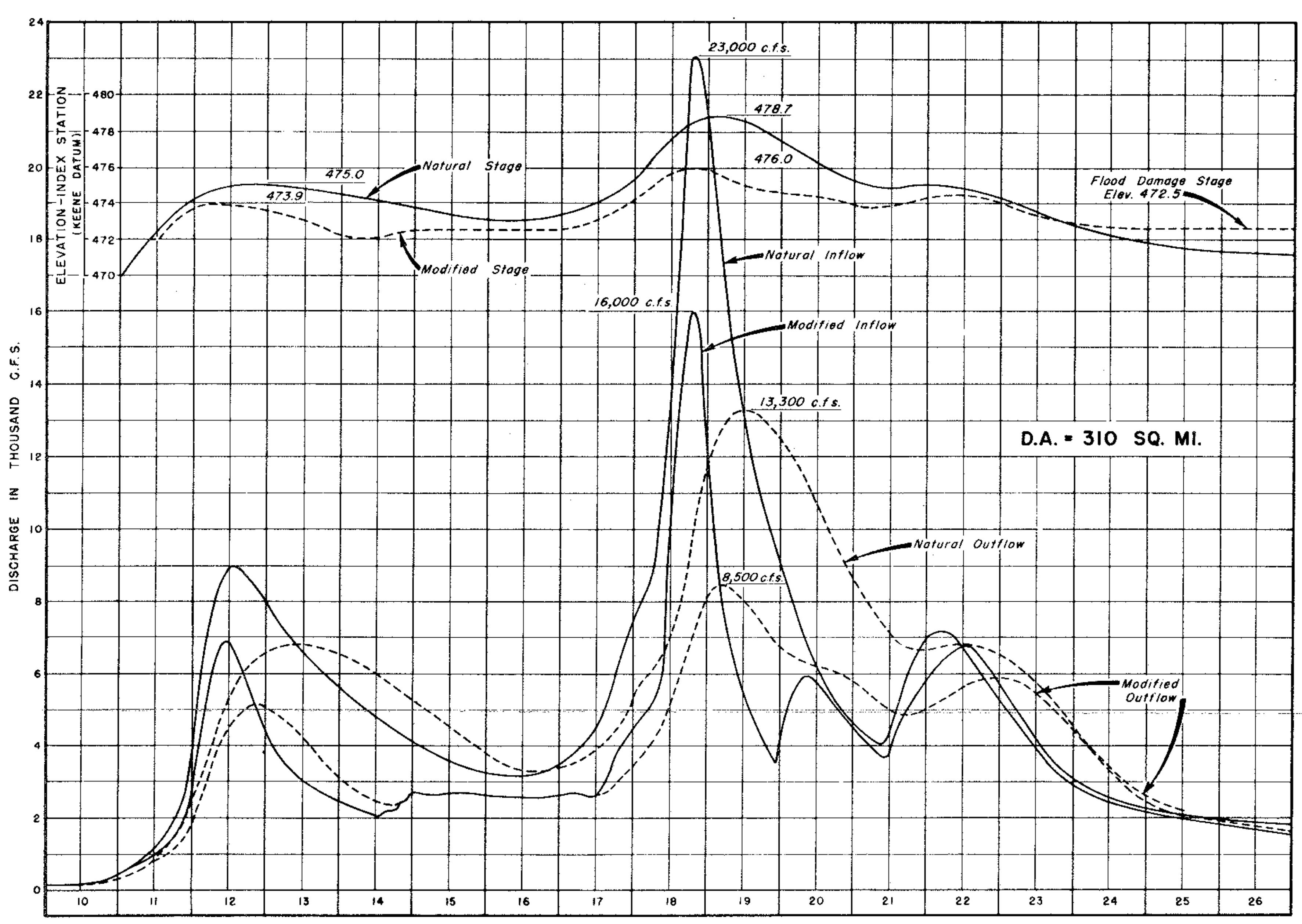
PLATE E-22



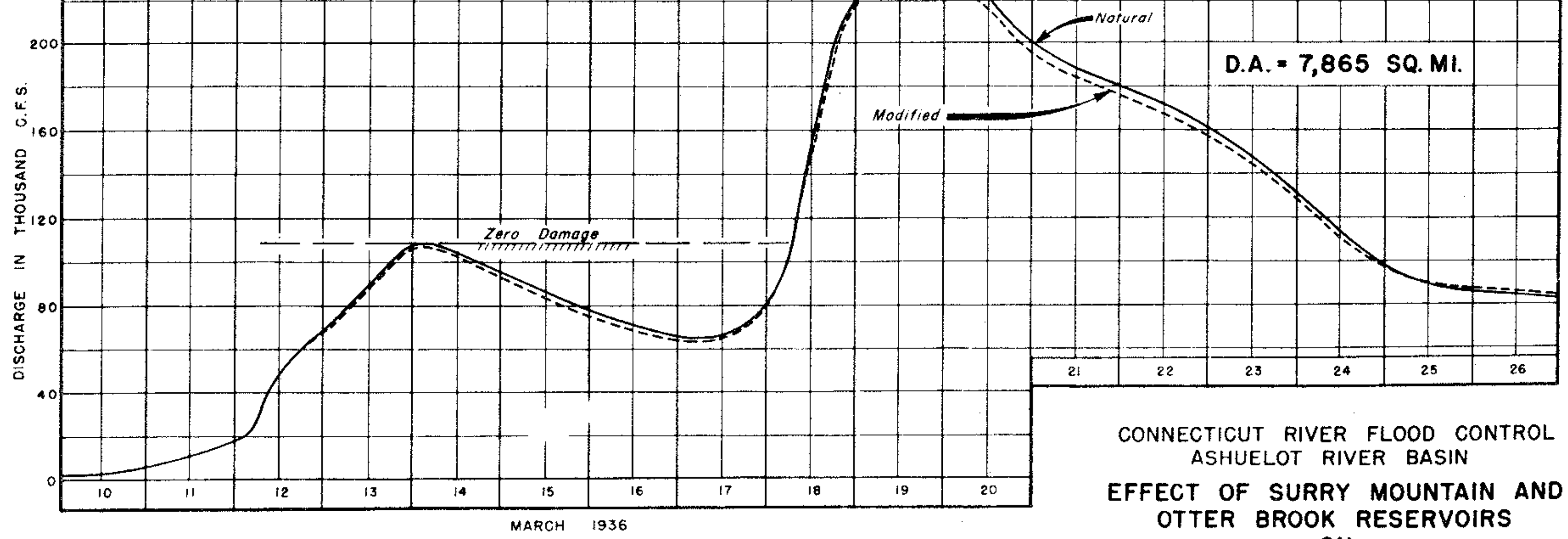
OTTER BROOK AT OTTER BROOK RESERVOIR



ASHUELOT RIVER AT SURRY MT. RESERVOIR



ASHUELOT RIVER AT KEENE, NEW HAMPSHIRE



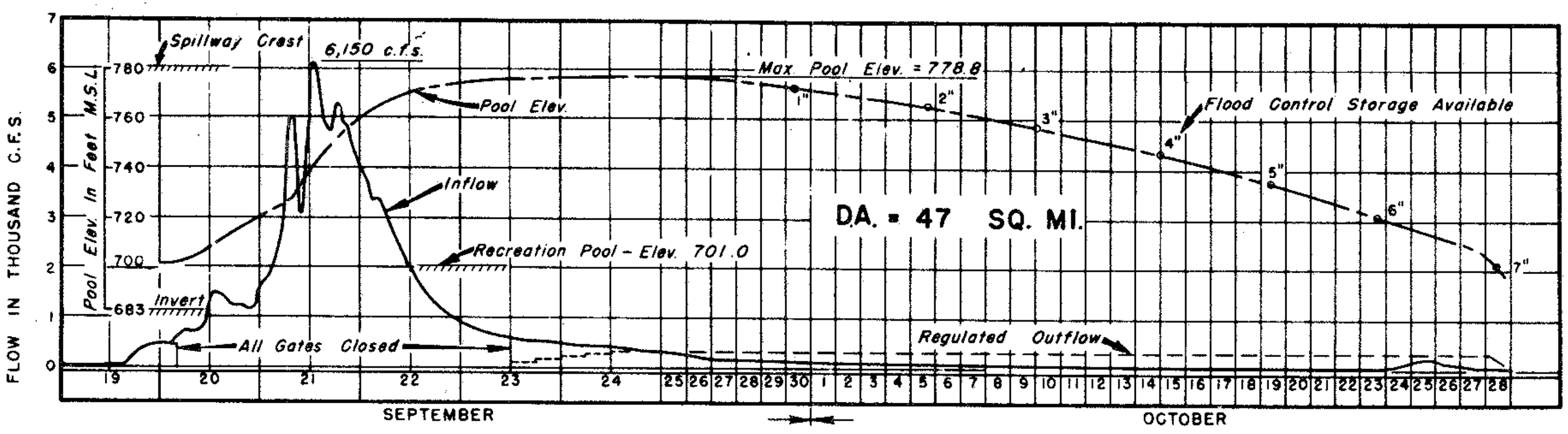
CONNECTICUT RIVER AT MONTAGUE CITY, MASSACHUSETTS

CONNECTICUT RIVER FLOOD CONTROL
ASHUELOT RIVER BASIN

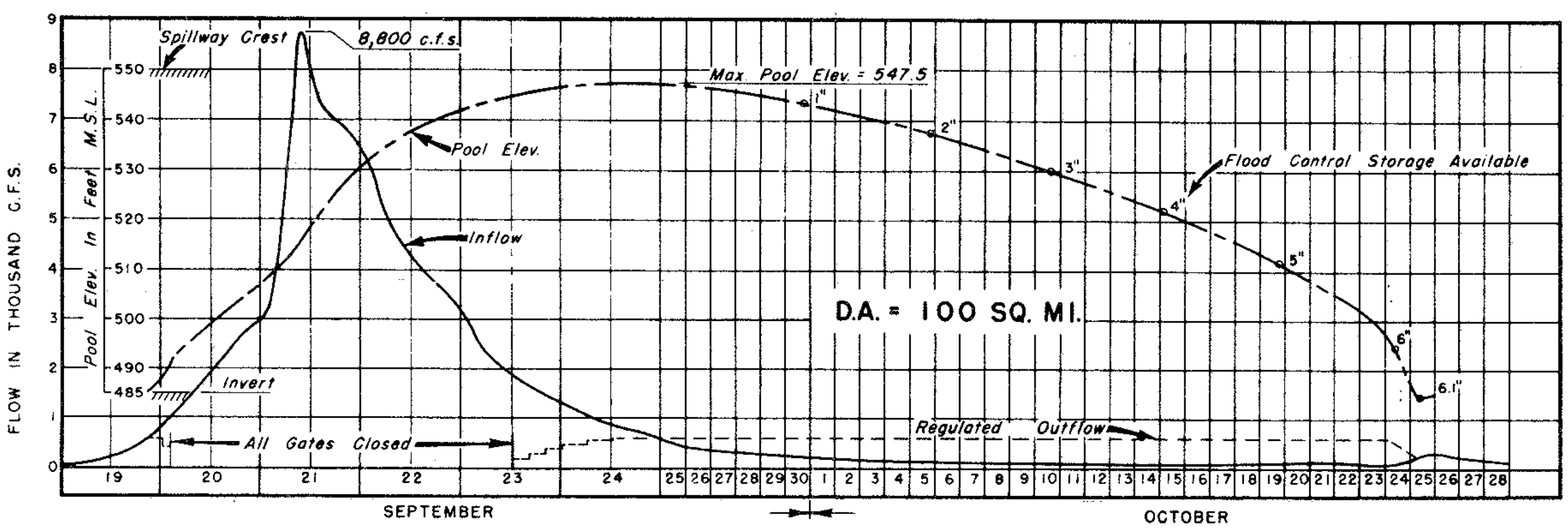
EFFECT OF SURRY MOUNTAIN AND OTTER BROOK RESERVOIRS ON FLOOD OF MARCH 1936

NEW ENGLAND DIVISION, WALTHAM, MASS.
DECEMBER 1961

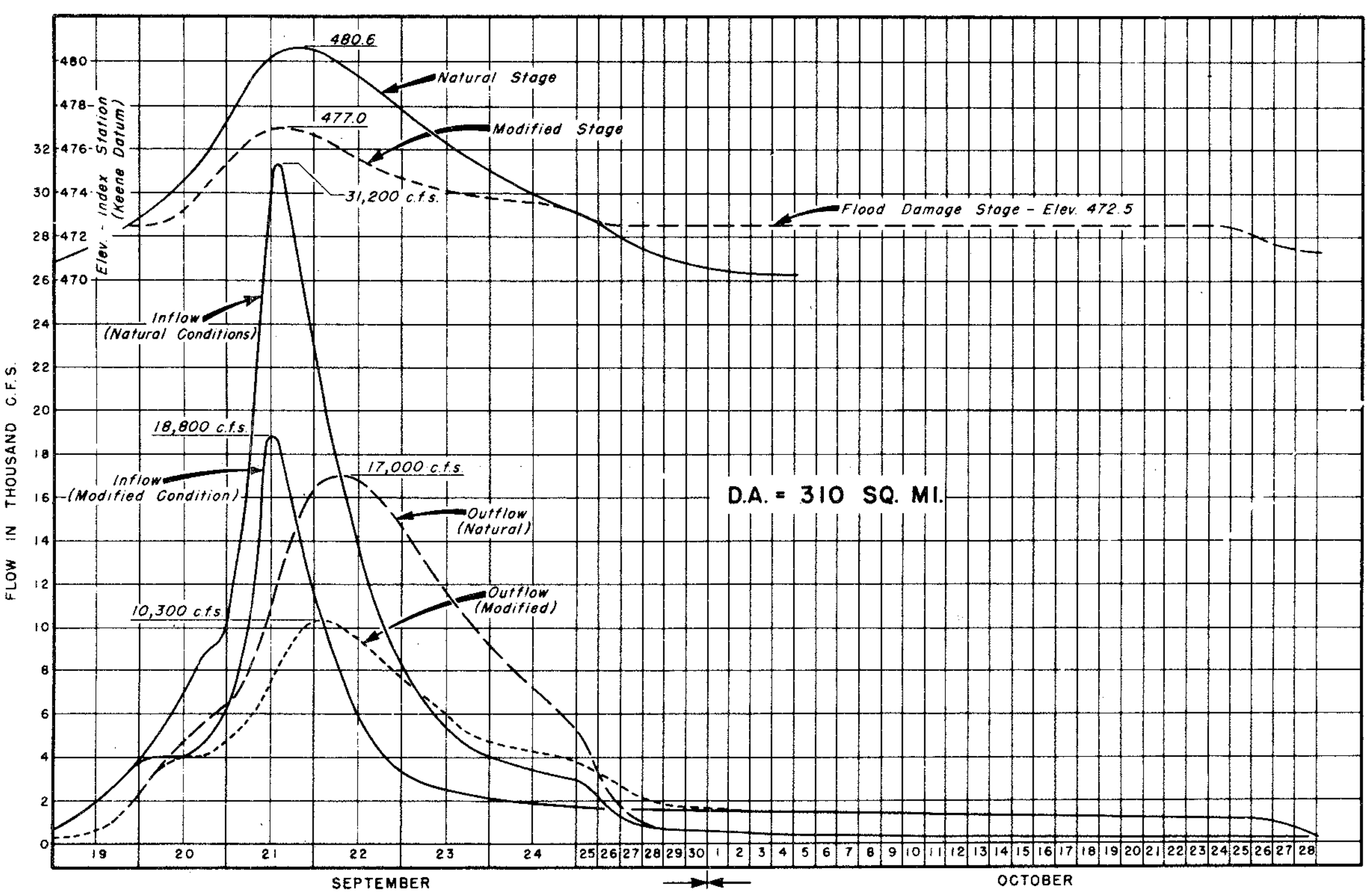
PLATE E-23



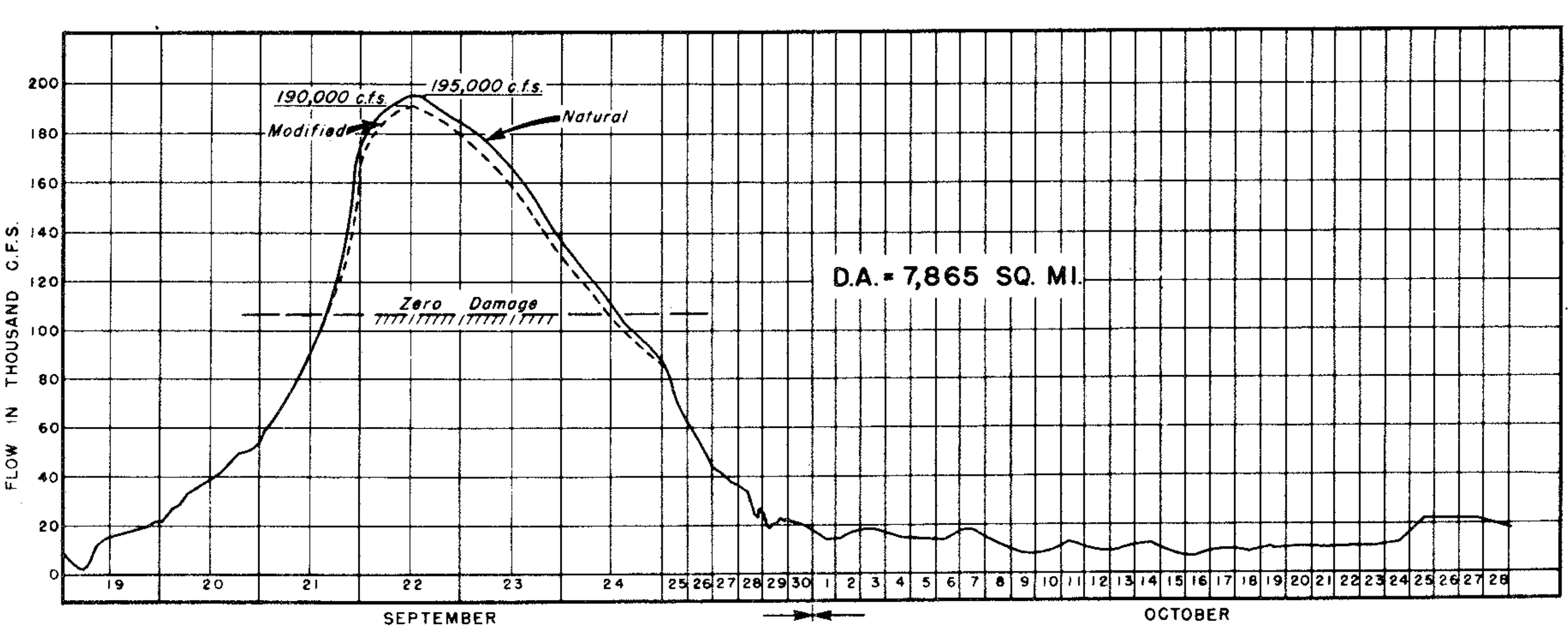
OTTER BROOK AT OTTER BROOK RESERVOIR



ASHUELOT RIVER AT SURRY MT. RESERVOIR



ASHUELOT RIVER AT KEENE, NEW HAMPSHIRE



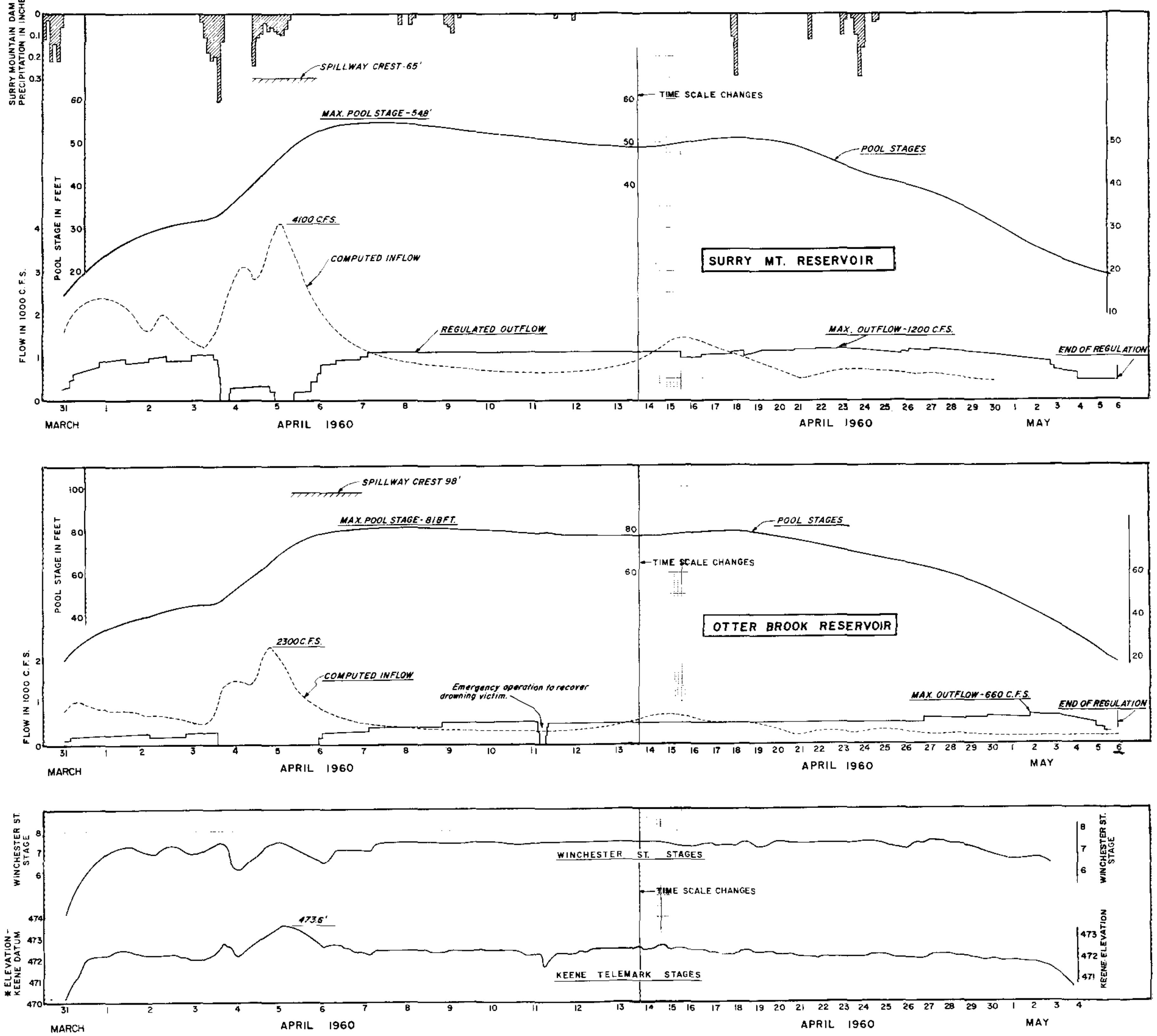
CONNECTICUT RIVER AT MONTAGUE CITY, MASSACHUSETTS

CONNECTICUT RIVER FLOOD CONTROL
ASHUELOT RIVER BASIN

EFFECT OF SURRY MOUNTAIN AND OTTER BROOK RESERVOIRS ON FLOOD OF SEPTEMBER 1938

NEW ENGLAND DIVISION, WALTHAM, MASS.
DECEMBER 1961

PLATE E-24



* - KEENE DATUM IS 5.3' ABOVE M.S.L.

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY | TR. BY M.W.B. | CK. BY

PROJECT ENGINEER

CHIEF, SECTION

SUBMITTED BY

CHIEF, PLANNING & REPTS BRANCH

CONNECTICUT RIVER FLOOD CONTROL

EFFECT OF SURRY MOUNTAIN AND OTTER BROOK RESERVOIRS ON THE APRIL 1960 FLOOD

ASHUELOT RIVER NEW HAMPSHIRE

APPROVED

CHIEF, ENGINEERING DIV.

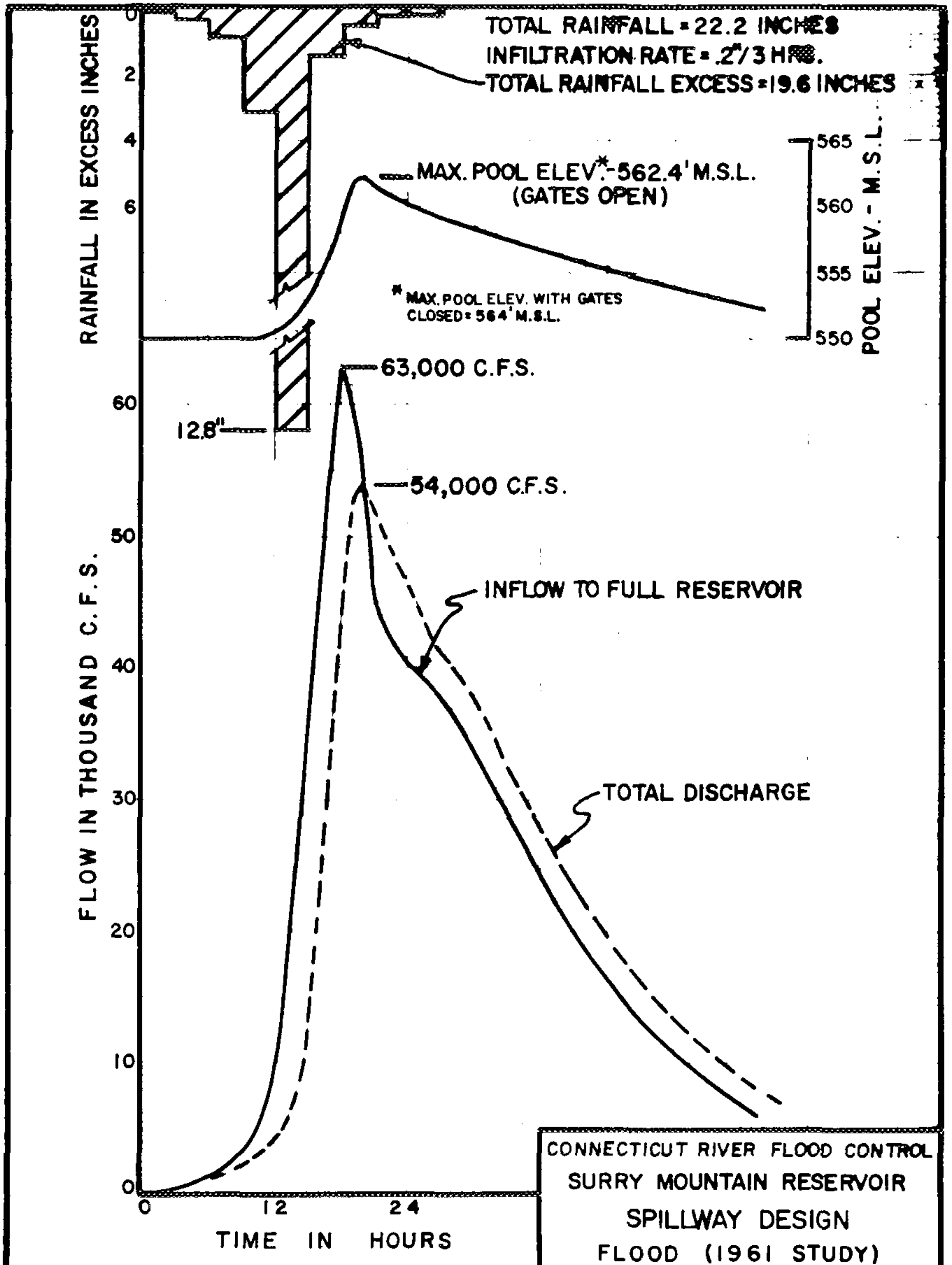
DATE FEB. 1962

SCALE

SPEC. NO. CIV. ENG.-19-016-

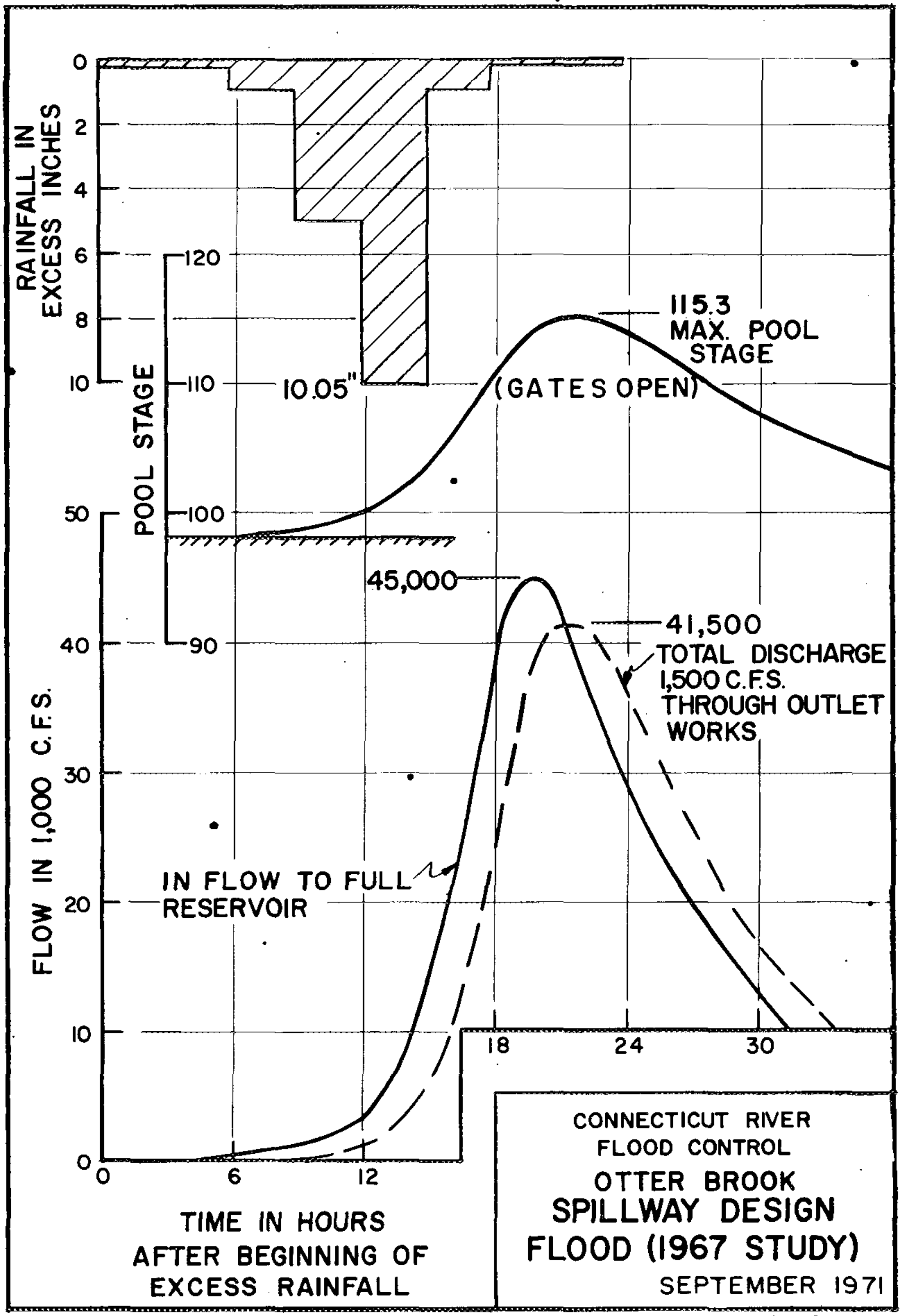
DRAWING NUMBER

SHEET



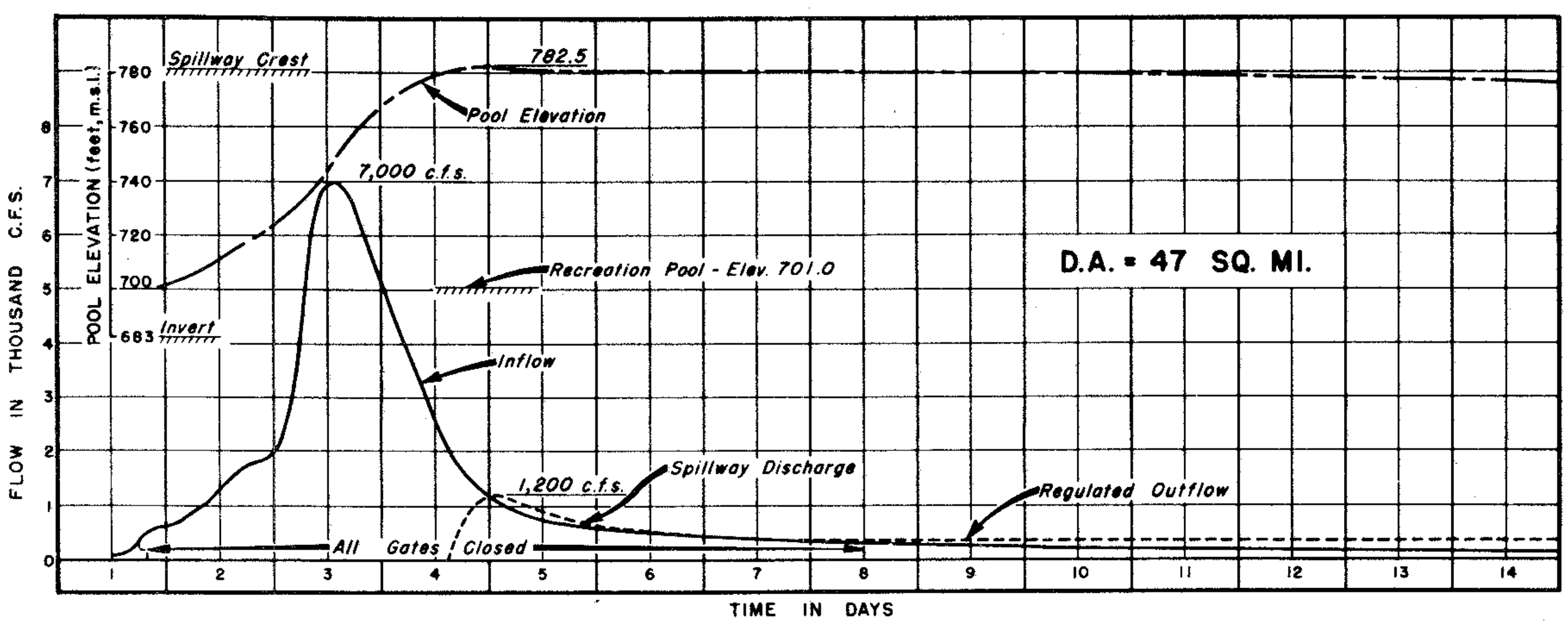
CONNECTICUT RIVER FLOOD CONTROL
SURRY MOUNTAIN RESERVOIR
SPILLWAY DESIGN
FLOOD (1961 STUDY)
NEW ENGLAND DIVISION WALTHAM, MASS.
FEBRUARY 1962

PLATE E-26

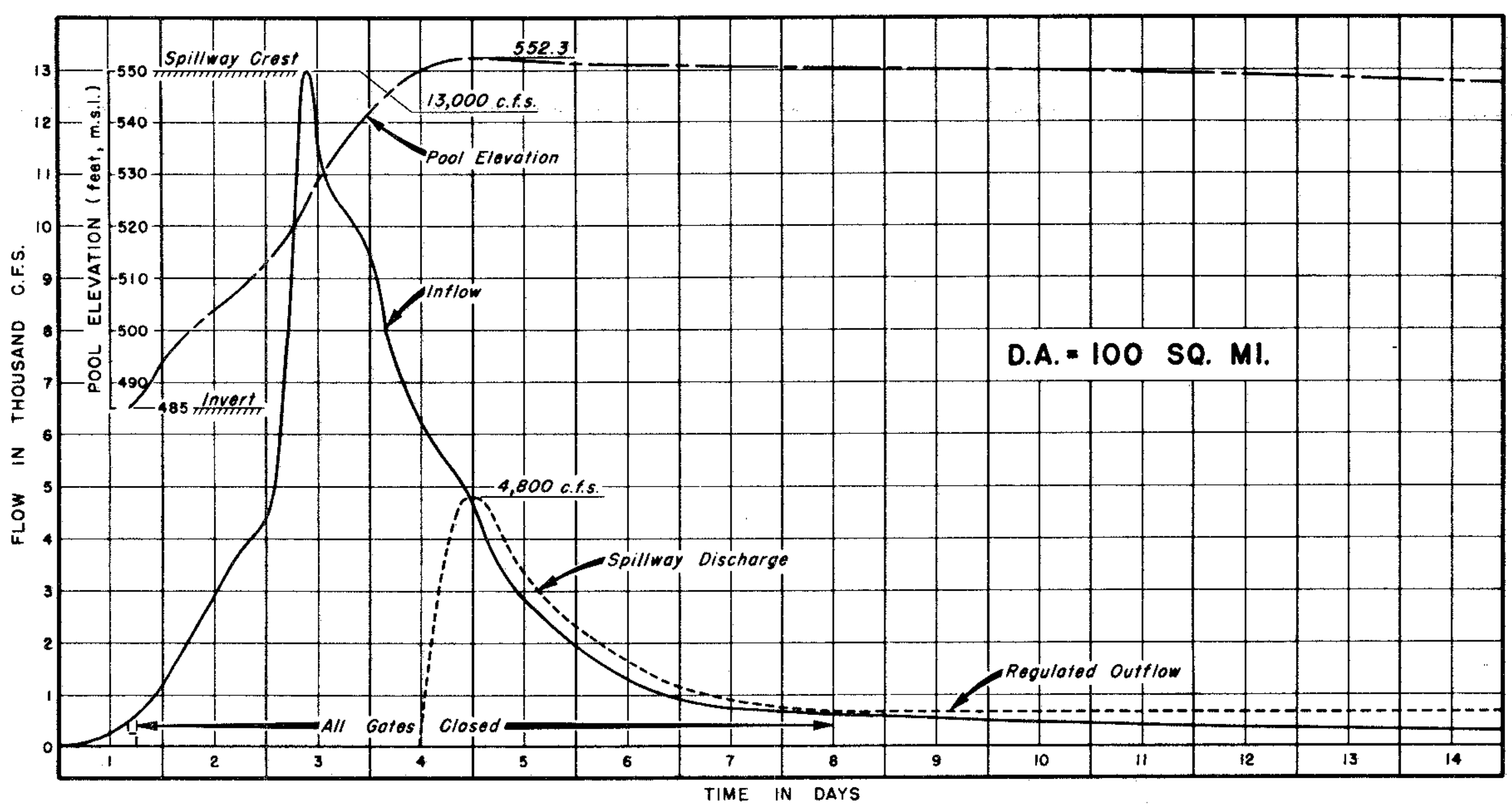


CONNECTICUT RIVER
FLOOD CONTROL
OTTER BROOK
SPILLWAY DESIGN FLOOD (1967 STUDY)
SEPTEMBER 1971

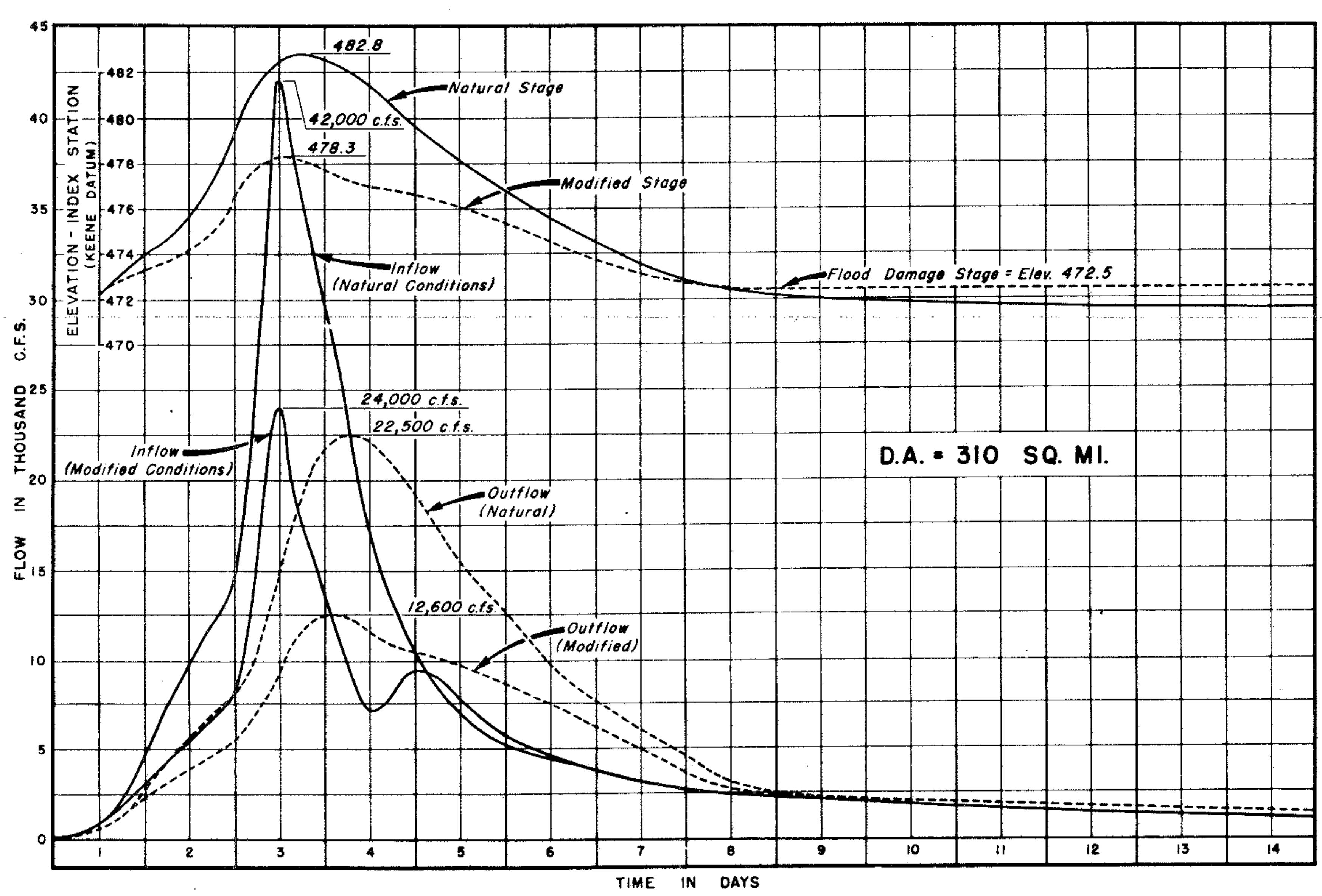
PLATE E-27



OTTER BROOK AT OTTER BROOK RESERVOIR



ASHUELOT RIVER AT SURRY MT. RESERVOIR



ASHUELOT RIVER AT KEENE, NEW HAMPSHIRE

CONNECTICUT RIVER FLOOD CONTROL
ASHUELOT RIVER BASIN

EFFECT OF SURRY MOUNTAIN AND OTTER BROOK RESERVOIRS ON STANDARD PROJECT FLOOD

NEW ENGLAND DIVISION, WALTHAM, MASS.
DECEMBER 1961

LOG OF RADIO REPORTS - FLOOD CONTROL DAMS

	WUA	32	42	40	39	45	33	320	24	512	38	593	25	250	
Line	ITEM	UNION VILLAGE	NORTH HARTLAND	NORTH SPRINGFIELD	BALL MOUNTAIN	TOWNSHEND	SURRY MOUNTAIN	OTTER BROOK	BIRCH HILL	TULLY	BARRE FALLS	LITTLEVILLE	KNIGHTVILLE	COLEBROOK RIVER	Line
1	Time of Observation														1
2	Precipitation (last 24 hours)														2
3	Form of Precipitation														3
4	Present Weather														4
5	Pool Stage														5
6	Tendency														6
7	Gate Openings														7
8	Tailwater Gage														8
9	Outflow														9
10	INDEX POINTS	Conn. R. @ Wells R.	Conn. R. @ White R. Jct.	Gear Shaper	West R. @ Jamaica	West R. @ Newfane	Ashuelot R. @ Keene	Ashuelot R. @ Keene	Conn. R. @ Montague City		Chicopee R @ Ind. Orchard	West Branch Westfield R. @ Huntington	North R. @ Shattuckville	NEW BOSTON	10
11		White R. Jct.		Conn. R. @ N. Walpole			Island St.					Westfield R. near Westfield	Deerfield R. @ Charlemont	RIVERTON	11
12		West Hartford												STILL RIVER	12
13														COLLINSVILLE	13
14														RAINBOW	14
15														SANDY BROOK	15
	REMARKS	← ASCUTNEY RELAY →							← WACHUSETT RELAY →				← GOSHEN RELAY →		
	NED [illegible] 477														

REGUL/OIRS

RCS NEDED-3

NED FORM APR 65 503

DATE AND TIME OF REPORT	RES POOL		GATE OPER						RIVER AT					
	HOUR	STAGE	1	2	3	4	5	F.S	HOUR	STAGE	C.F.S	HOUR	STAGE	C.F.S

GATE OPERATION RECORD

SURRY MOUNTAIN **RESERVOIR** JANUARY **MONTH** 1972 **YEAR**

SAMPLE
OPERATOR

I.D.	DAY	HOUR	RES. STAGE	OUTFLOW	PRECIP.	T. W.	GATE SETTING 1	GATE SETTING 2	GATE SETTING 3	GATE SETTING 4	GATE SETTING 5	GATE SETTING 6	GATE SETTING 7	GATE SETTING 8	REMARKS
66	15	0800	19.20	242	.	6.18	2.0	0.5							
	16	0800	19.64	304	.03	6.40	2.0	0.5							(Snow-1")
	17	0800	19.11	304	.	6.40	2.0	0.5							
	18	0800	18.54	295	.	6.37	2.0	0.5							
66	19	0800	17.99	290	. T	6.35	2.0	0.5							(Rain-T)
	20	0800	17.34	281	.	6.32	2.0	0.5							
	21	0800	16.52	265	.32	6.26	2.0	0.5							(Snow-4")
	21	0900	16.52	253	.	6.22	2.0	0.0							

NED FORM SEP 70 90 REPLACES EDITION OF MAR 62 WHICH IS OBSOLETE

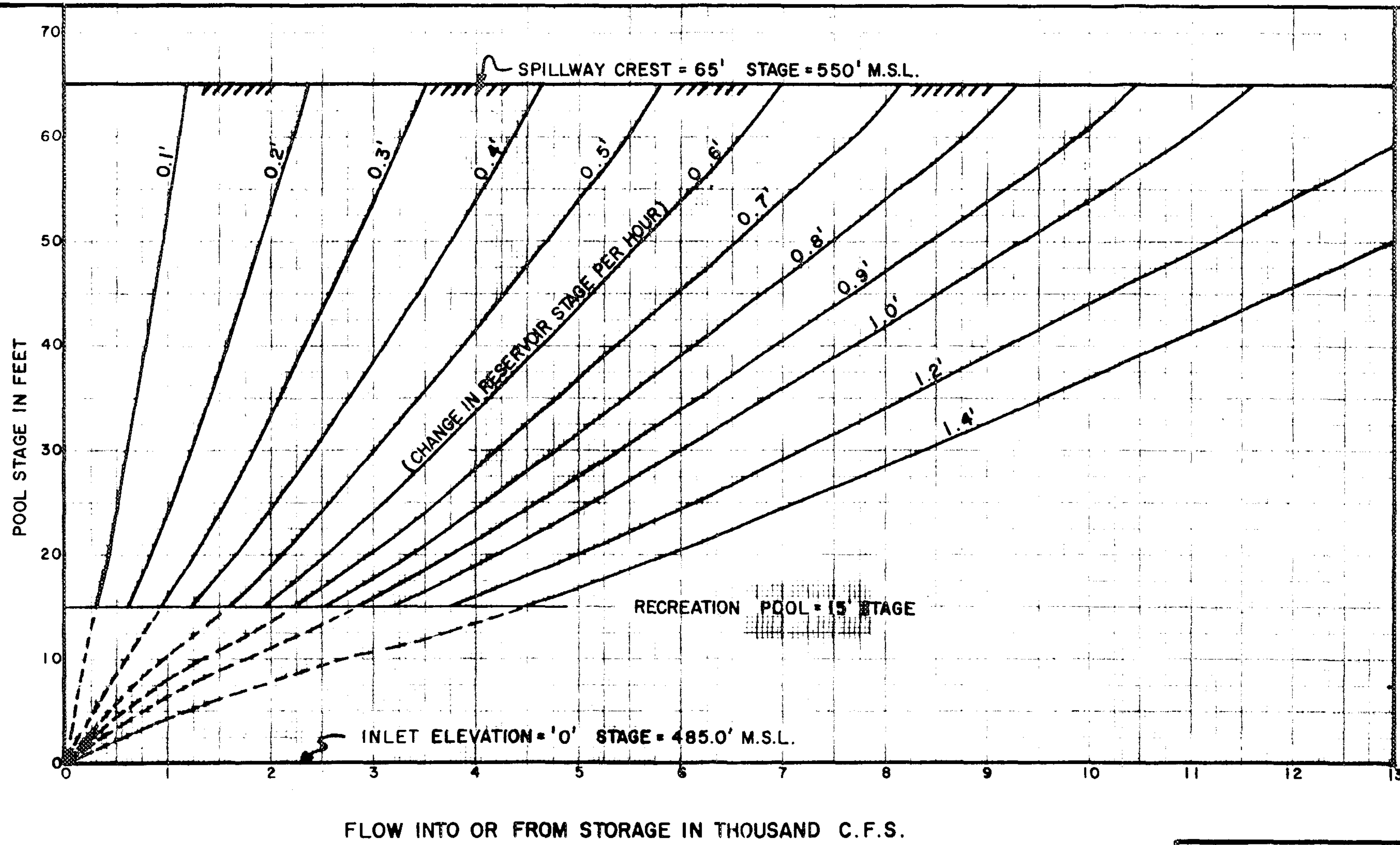
NED FORM 102
15 Nov. 1951

RESERVOIR REGULATION
COMPUTATION OF INFLOW

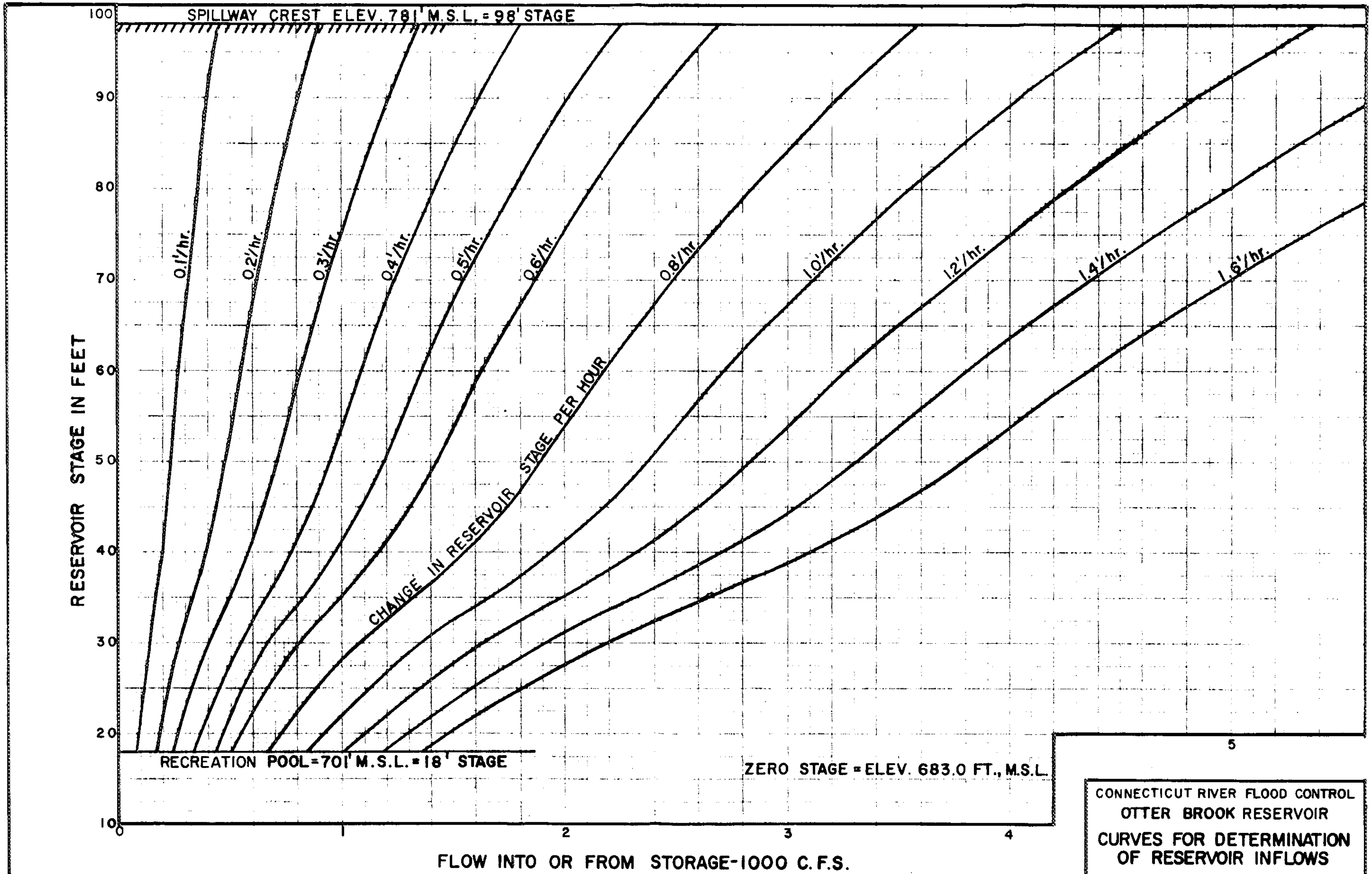
Flood of OCT 1959

Reservoir SURRY MT. By SAMPLE Date 26 OCT 1959

TIME	RES. STAGE Feet	CHANGE IN RES. STAGE Feet per hour Observed	Adjusted	FLOW into/from STORAGE c. f. s.	OUTFLOW c. f. s.	TOTAL INFLOW (5) + (6) c. f. s.	REMARKS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
9-24-59							
2200	21.0				35		
	21.75	1.5	0.75	3360		3395	
2400	22.5				35		
	23.25	1.5	0.75	3540		3575	
9-25-59							
0200	24.0				35		
	24.7	1.4	0.7	3520		3555	
0400	25.4				35		
	26.0	1.2	0.6	3150		3185	
0600	26.6				35		
	27.25	1.3	0.65	3550		3585	
0800	27.9				35		
	28.45	1.1	0.55	3100		3135	
1000	29.0				35		
	29.45	0.9	0.45	2640		2675	
1200	29.9				35		
	30.45	1.1	0.55	3320		3355	
1400	31.0				35		
	31.4	0.8	0.4	2480		2515	
1600	31.8				35		
	32.15	0.7	0.35	2220		2255	
1800	32.5				35		
	32.85	0.7	0.35	2260		2295	
2000	33.2				35		
	33.55	0.7	0.35	2310		2345	
2200	33.9				35		
	34.2	0.6	0.3	1750		1785	
2400	34.5				35		
	34.75	0.5	0.25	1690		1725	
9-26-59							
0200	35.0				35		
	35.25	0.5	0.25	1720		1755	
0400	35.5				35		
	35.75	0.5	0.25	1740		1775	
0600	36.0				35		
	36.25	0.5	0.25	1760		1795	
0800	36.5				35		
	36.7	0.4	0.2	1430		1465	
							PLATE E-32



CONNECTICUT RIVER FLOOD CONTROL
SURRY MOUNTAIN RESERVOIR
CURVES FOR DETERMINATION OF RESERVOIR INFLOWS
NEW ENGLAND DIVISION WALTHAM, MASS.
FEBRUARY 1962



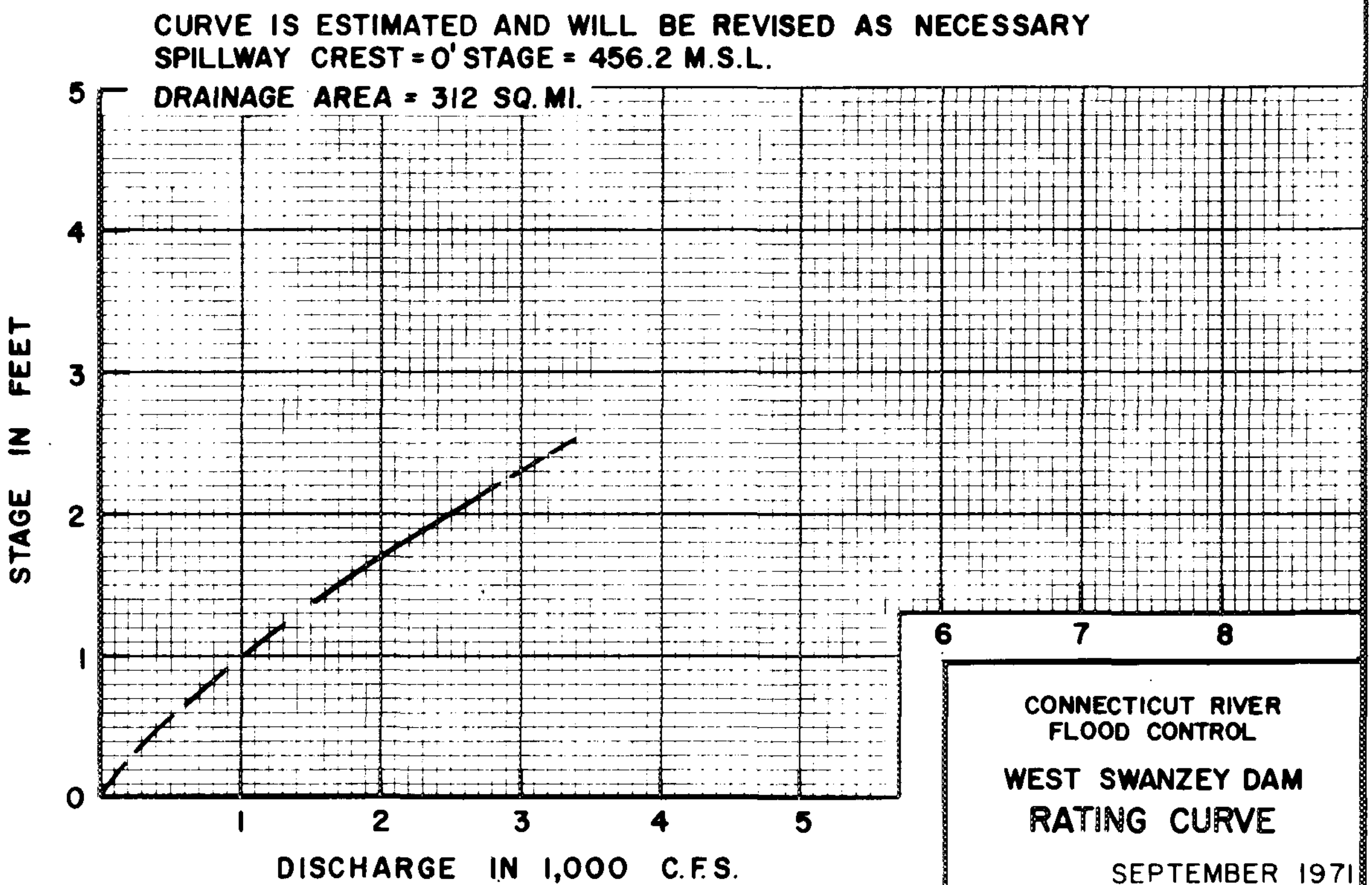
CONNECTICUT RIVER FLOOD CONTROL

OTTER BROOK RESERVOIR

CURVES FOR DETERMINATION OF RESERVOIR INFLOWS

NEW ENGLAND DIVISION WALTHAM, MASS.
FEBRUARY 1962

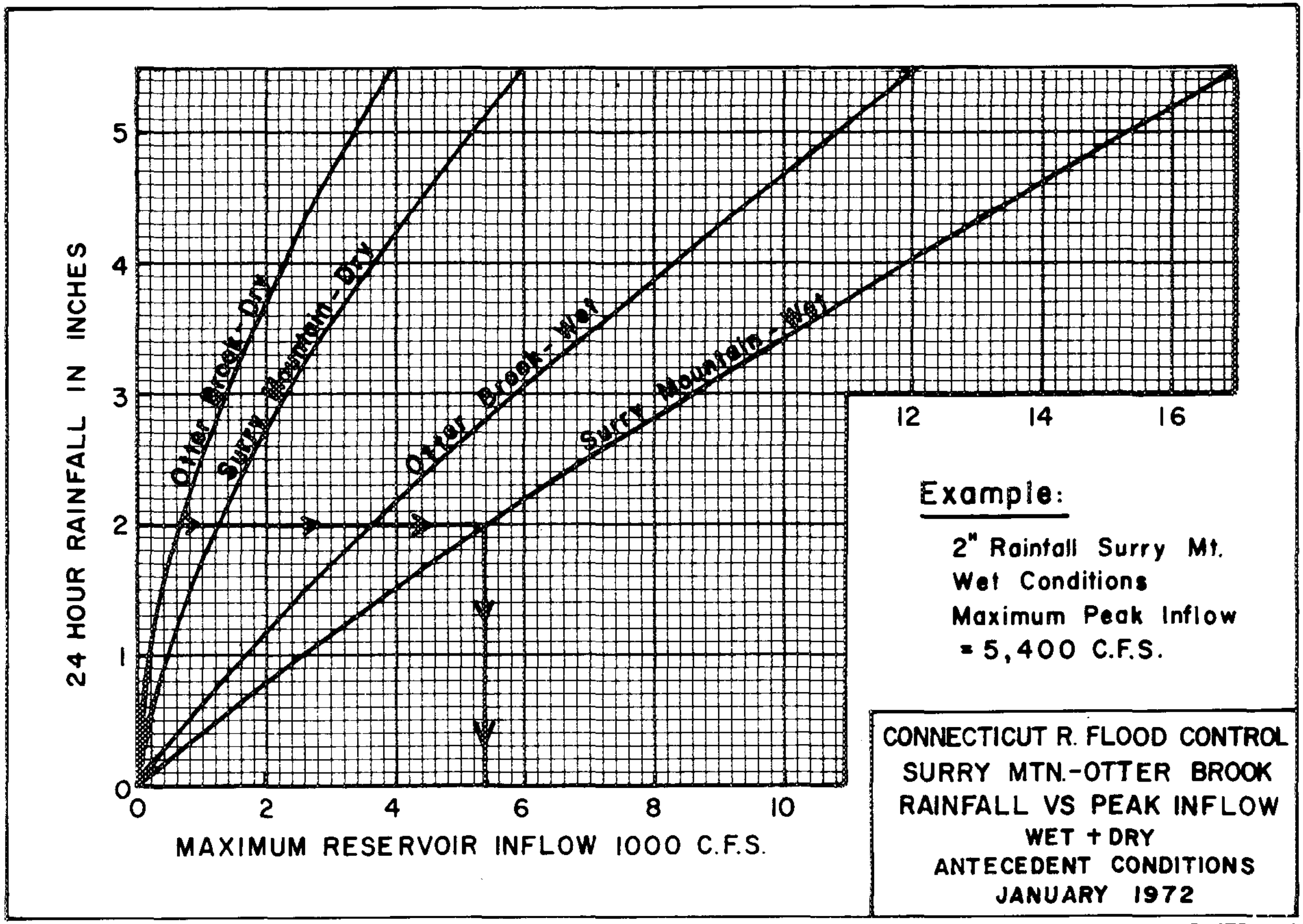
PLATE E-34



CONNECTICUT RIVER
FLOOD CONTROL

WEST SWANZEY DAM
RATING CURVE

SEPTEMBER 1971



24 HOUR RAINFALL IN INCHES
0
1
2
3
4
5
0
2
4
6
8
10
12
14
16
MAXIMUM RESERVOIR INFLOW 1000 C.F.S.
Otter Brook - Dry
Surry Mountain - Dry
Otter Brook - Wet
Surry Mountain - Wet
Example:
2" Rainfall Surry Mt.
Wet Conditions
Maximum Peak Inflow
= 5,400 C.F.S.
CONNECTICUT R. FLOOD CONTROL
SURRY MTN.-OTTER BROOK
RAINFALL VS PEAK INFLOW
WET + DRY
ANTECEDENT CONDITIONS
JANUARY 1972

STANDARD OPERATING PROCEDURE (SOP)
FLOOD CONTROL REGULATION
SURRY MOUNTAIN AND OTTER BROOK LAKES

PHASE	STORM RAINFALL (WITHIN 24-HR. PERIOD) ANTECEDENT CONDITIONS: SNOW-COV'R'D WET OR FROZEN GROUND	STORM RAINFALL: DRY GROUND	SURRY MOUNTAIN LAKE POOL STAGE FEET	OTTER BROOK LAKE POOL STAGE FEET	RIVER INDEX STATIONS (STAGE IN FEET) ASHUELOT RIVER AT ISLAND STREET	ASHUELOT RIVER AT KEENE TELEMARK	CONN. RIVER MONTAGUE CITY	REGULATION INSTRUCTIONS GATE SETTINGS SURRY MOUNTAIN	REGULATION INSTRUCTIONS GATE SETTINGS OTTER BROOK
I - APPRAISAL FIRST ALERT	1.0"	1.0"	SUMMER 18 (RISING)	SUMMER 21 (RISING)	—	—	—	NORMAL SETTING	
SECOND ALERT	1.5" (Or As Instructed)	1.5"	WINTER 19 (RISING) As Instructed	WINTER 24 (RISING) As Instructed					
INITIAL REGULATION	2.0" (Or As Instructed)	2.0"	As Instructed	As Instructed	—	471.0	—	DISCHARGE SHOULD NOT EXCEED 750 CFS	DISCHARGE SHOULD NOT EXCEED 350 CFS
II - CONTINUATION OF REGULATION	3.0" (Or As Instructed)	3.0"	As Instructed	As Instructed	7.0 *	472.5	25.0 (64,000 C.F.S.) Or As Instructed	RESTRICT OUTFLOW TO 10 C.F.S.	
III - EVACUATION OF POOLS	STORM HAS ABATED		FOR ALLOWABLE RELEASE RATES, CONSULT GUIDE CURVES ON PLATE E-38 THE SAFE DOWNSTREAM CHANNEL CAPACITY FOR SURRY MOUNTAIN NON-GROWING SEASON IS 1200 C.F.S., GROWING SEASON 800 C.F.S., OTTER BROOK 600 C.F.S.						

DUTIES DURING EACH PHASE

FLOOD CONTROL DAM OPERATOR

PHASE I

1. COLLECT AND TRANSMIT RAINFALL AND STAGE DATA TO RCC.
2. OPERATE ACCORDING TO INSTRUCTIONS FROM RCC.

PHASE II

1. OPERATE ACCORDING TO INSTRUCTIONS FROM RCC.
2. NOTE ALL UNUSUAL CONDITIONS OF DAM, DOWNSTREAM CHANNELS AND INDEX STATIONS.
3. COLLECT AND TRANSMIT RAINFALL AND STAGE DATA AT MINIMUM 3-HOUR INTERVALS OR AS DIRECTED BY RCC.

PHASE III

1. SEE PHASE II, STEP 3.
2. RECONNOITER DOWNSTREAM CHANNELS AND POTENTIAL DAMAGE AREAS.
3. REPORT TO RCC FOR FURTHER INSTRUCTIONS.

PROJECT REGULATOR

PHASE I

1. COMPILE DATA.
2. PLAN AND COORDINATE NEXT TRANSMISSION TO DAM OPERATOR.
3. RESTRICT OUTFLOW TO MAINTAIN SAFE CHANNEL CAPACITY IN THE ASHUELOT RIVER.
4. INFORM CONNECTICUT RIVER BASIN REGULATOR OF ACTIONS.

PHASE II

1. CONTINUE REGULATION INSTRUCTIONS TO DAM OPERATORS.
2. CONSULT WITH BASIN REGULATOR TO ANALYZE SEVERITY OF FLOOD.
3. COORDINATE REGULATION WITH CONNECTICUT RIVER BASIN REGULATOR.

PHASE III

1. COLLECT DATA FROM DAM OPERATORS.
2. CHECK GUIDE CURVES FOR ALLOWABLE RELEASES.
3. CONSULT WITH CONNECTICUT RIVER BASIN REGULATOR.
4. TRANSMIT INSTRUCTIONS TO DAM OPERATORS.

EMERGENCY OPERATING PROCEDURE (EOP)
(During Communication Failure with RCC)

COMPLETE GATE CLOSURE FOR ANY OF THE FOLLOWING CONDITIONS: GATE SETTINGS:

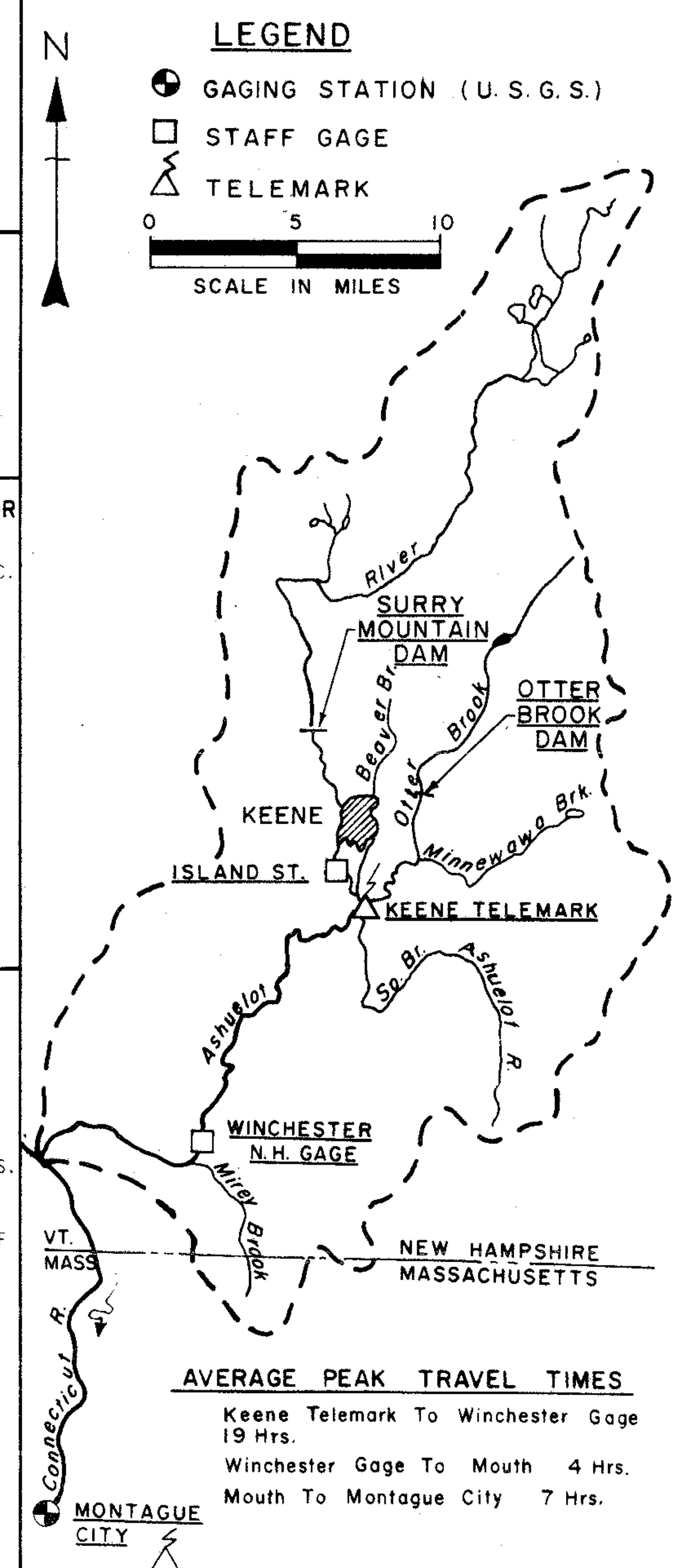
SURRY MOUNTAIN 0'-0.1'
OTTER BROOK 0'-0.1'-0'

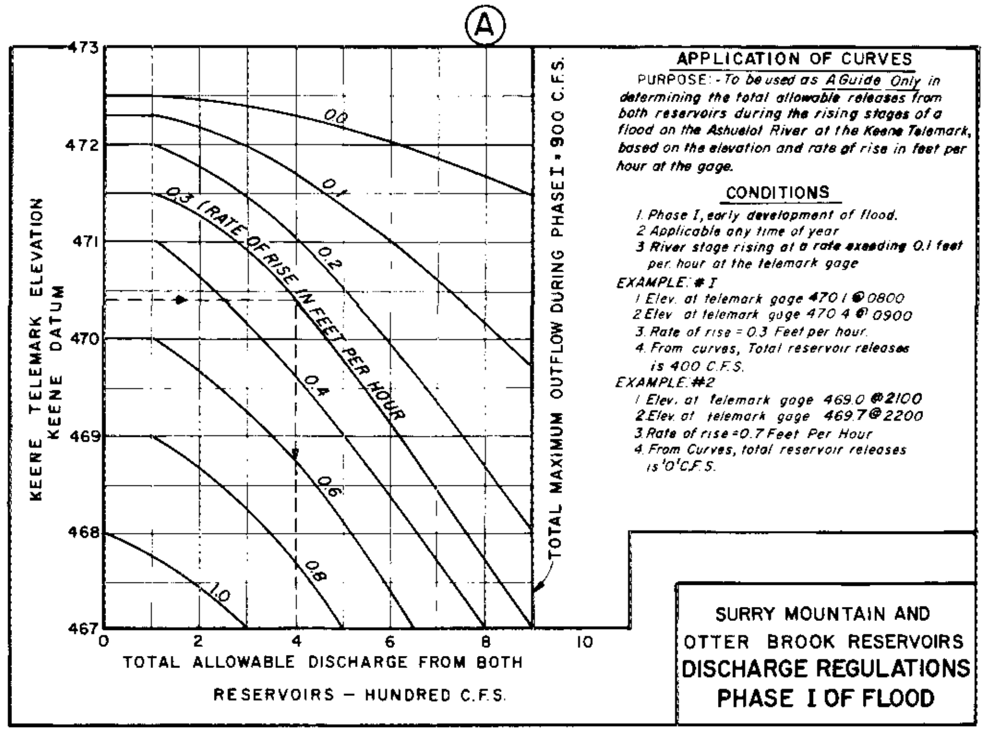
1. IF TWO INCHES OF RAINFALL OCCUR IN THE WATERSHED DURING ANY 24-HOUR PERIOD.
2. IF THE KEENE TELEMARK RISES TO A STAGE OF 471.5 FEET (LOCAL DATUM) AND IS STILL RISING.
3. IF THE CONNECTICUT RIVER AT MONTAGUE CITY RISES TO A STAGE OF 25 FEET.

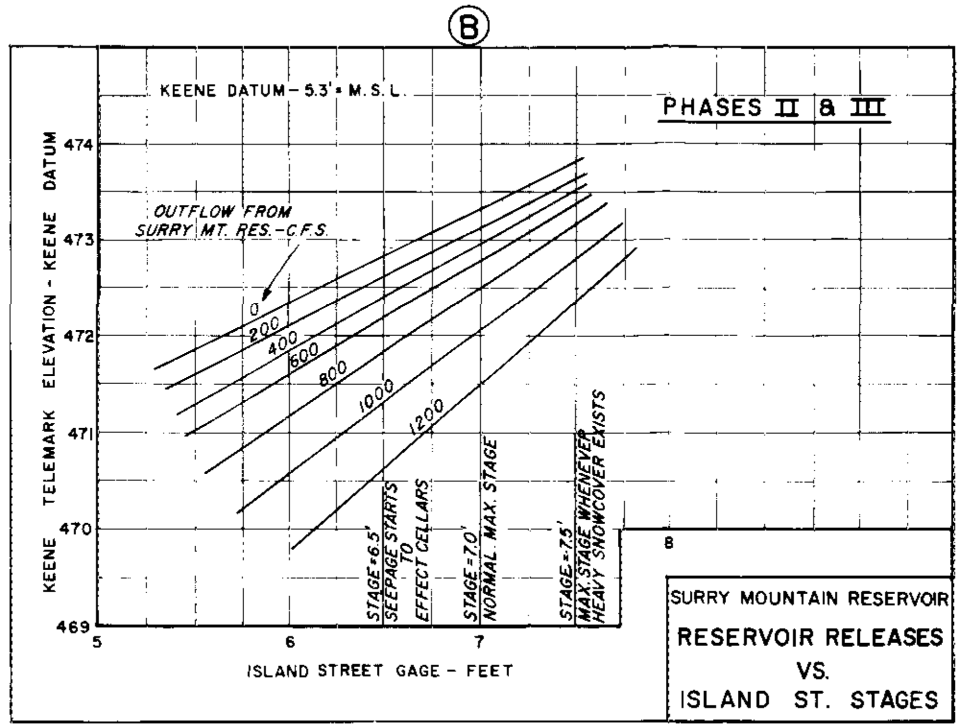
NOTES:

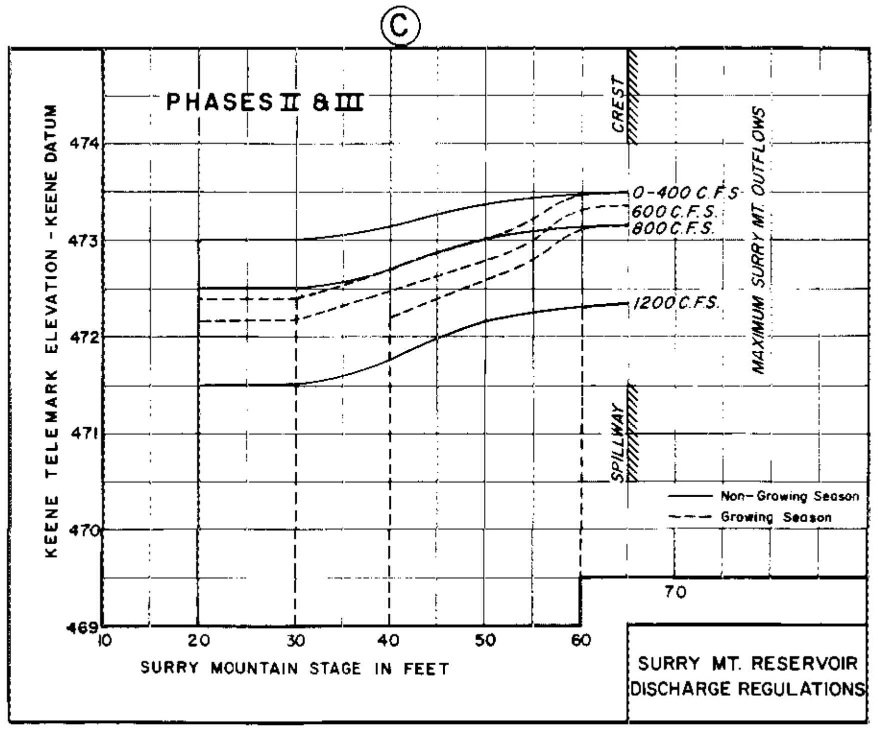
1. EMPTYING THE RESERVOIRS SHALL NOT BE INITIATED UNTIL CONTACT HAS BEEN ESTABLISHED WITH RCC.
2. THE RATE OF INCREASE IN RESERVOIR DISCHARGES FROM SURRY MOUNTAIN SHALL NOT EXCEED 200 CFS/2 HOURS UP TO 600 CFS, AND 100 CFS/2 HOURS OVER 600 CFS. THE RATE OF INCREASE IN RESERVOIR DISCHARGE FROM OTTER BROOK SHALL NOT EXCEED 200 CFS/2 HOURS.
3. MAXIMUM RATE OF RESERVOIR DRAWDOWN SHOULD NOT EXCEED:
   SURRY MOUNTAIN - 5 FOOT/24 HOURS
   OTTER BROOK - 10 FOOT/24 HOURS
4. REFER TO PARAGRAPH 27e FOR SNOWMELT REGULATION.
5. REFER TO PARAGRAPH 9c FOR ICE JAM FLOODING.
6. CONSIDER ROAD CLOSURES WHEN RISING POOLS ARE EXPECTED TO REACH THE FOLLOWING STAGES:
   SURRY MOUNTAIN: 18 FEET - ACCESS ROAD TO RECREATION WEIR
   35 FEET - OLD SURRY ROAD
   50 FEET - OLD POND ROAD
   OTTER BROOK: 27 FEET - ROAD TO LOW PARKING AREA

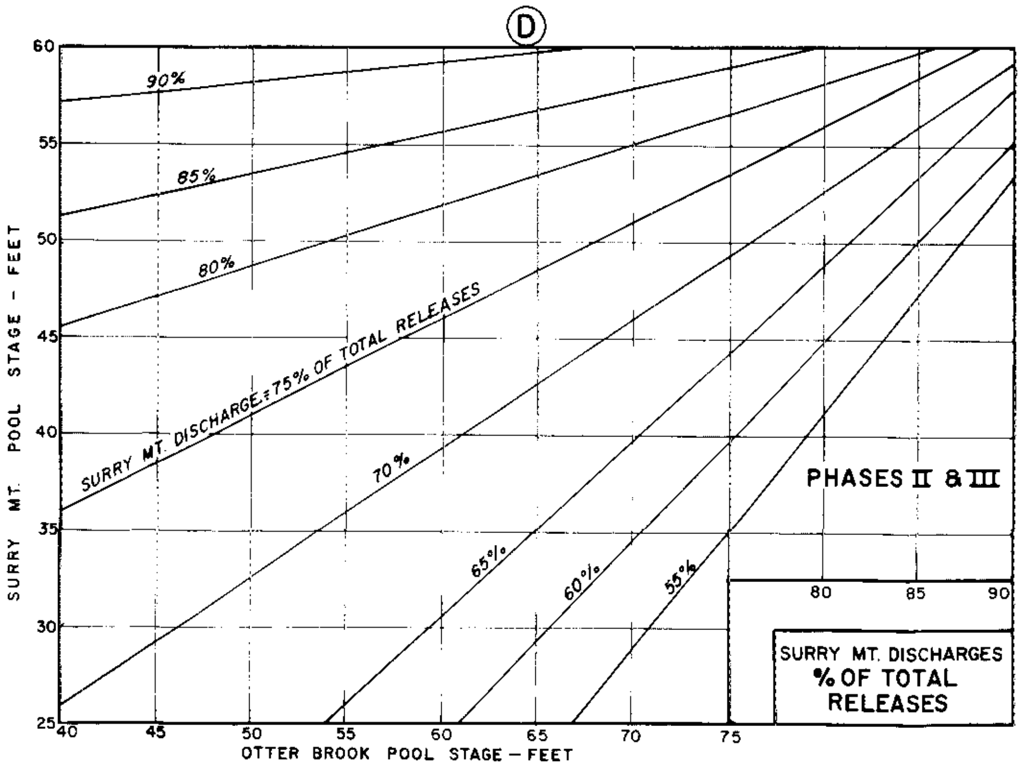
*7. REFER TO PHASE III, PARAGRAPH 27d FOR OPERATION INSTRUCTIONS WITH REGARD TO ISLAND STREET STAGES.
8. IF SPILLWAY DISCHARGE IS ANTICIPATED, REFER TO PARAGRAPH 27q ON AFFECTED POPULACE, AND PARAGRAPH 27f ON GATE RELEASE SCHEDULE ABOVE SPILLWAY CREST ELEVATION.











CONNECTICUT RIVER FLOOD CONTROL

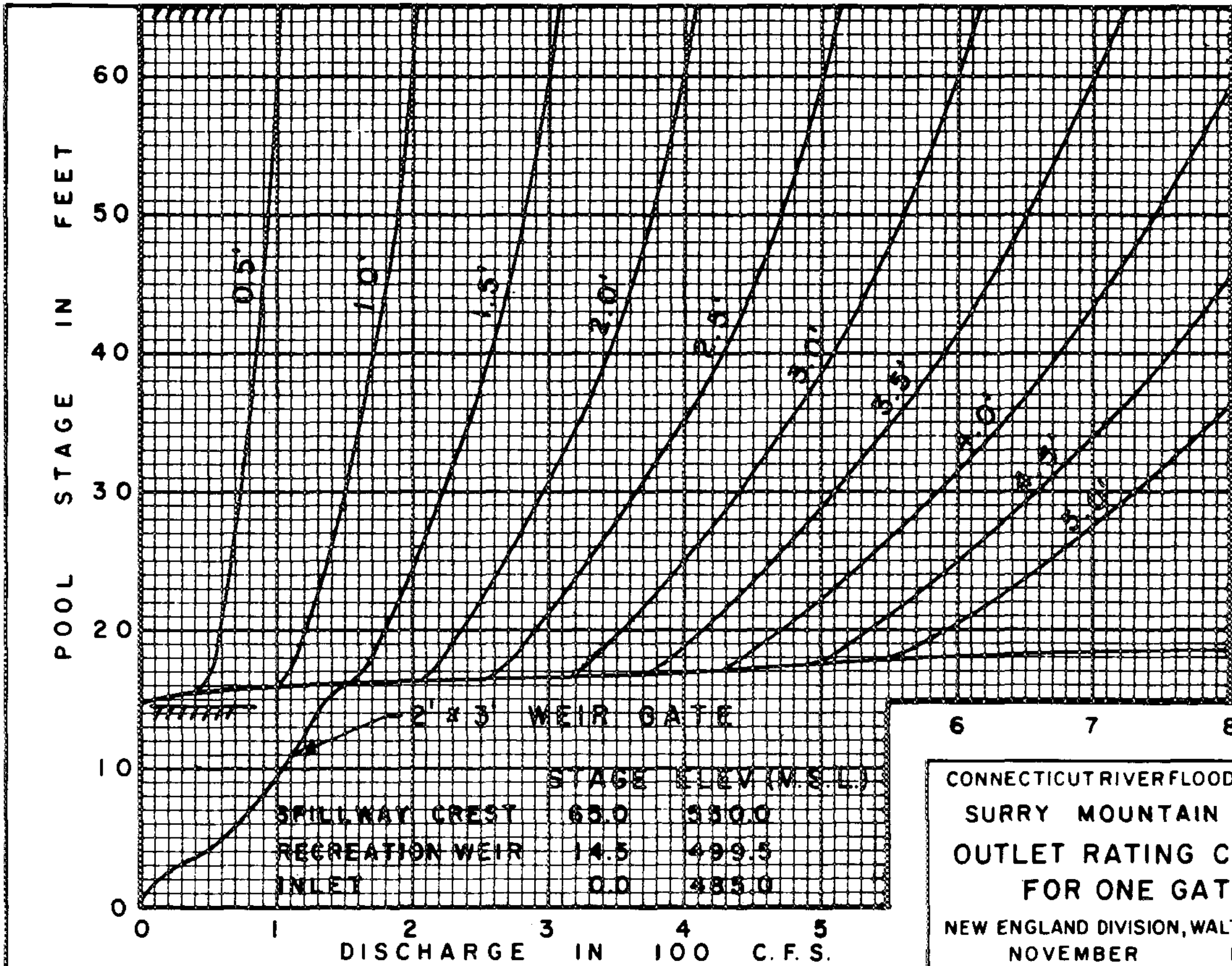
ASHUELOT RIVER BASIN

GUIDE CURVES FOR RESERVOIR REGULATION

NEW ENGLAND DIVISION WALTHAM, MASS.

FEBRUARY 1962

PLATE E-38

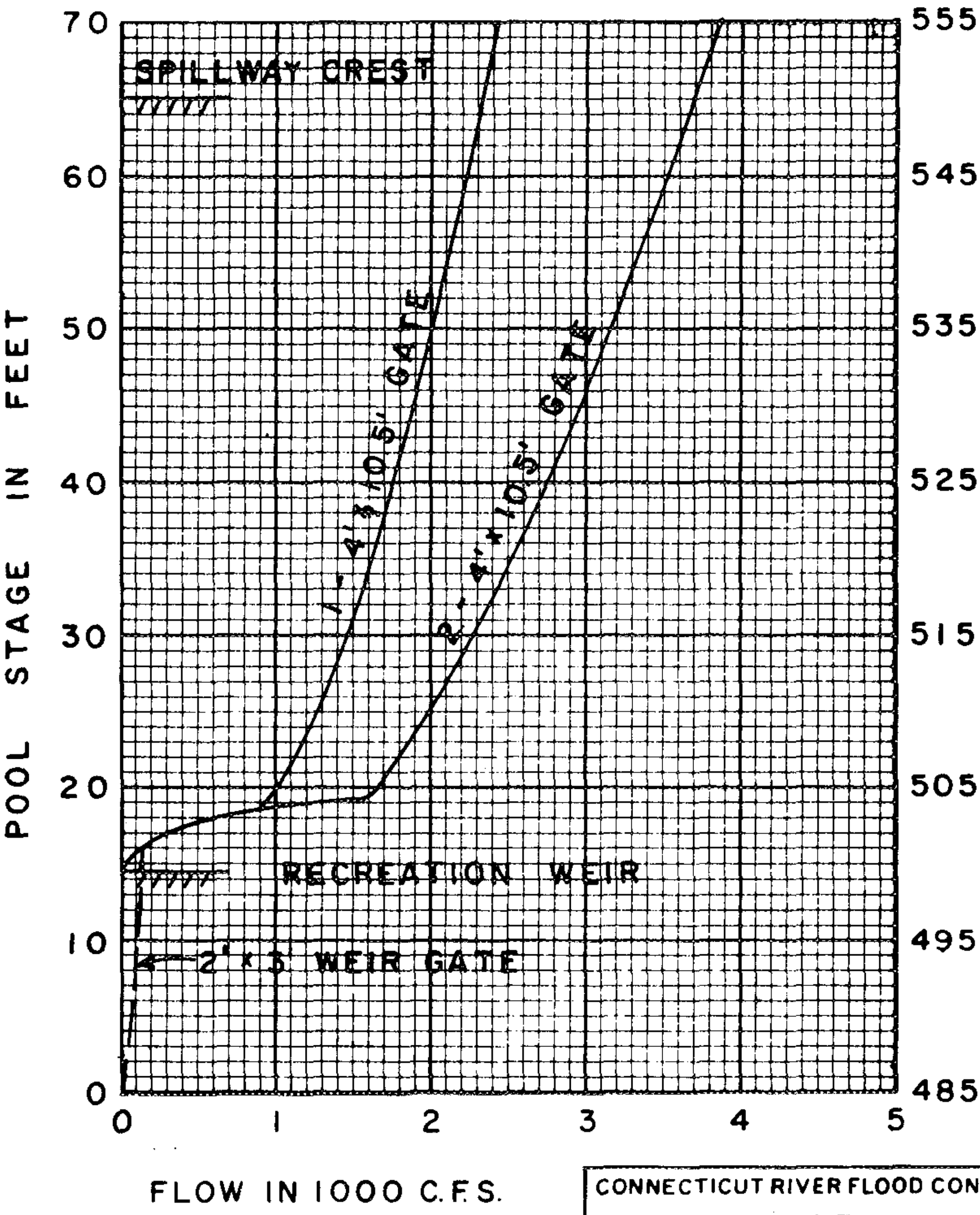


CONNECTICUT RIVER FLOOD CONTROL

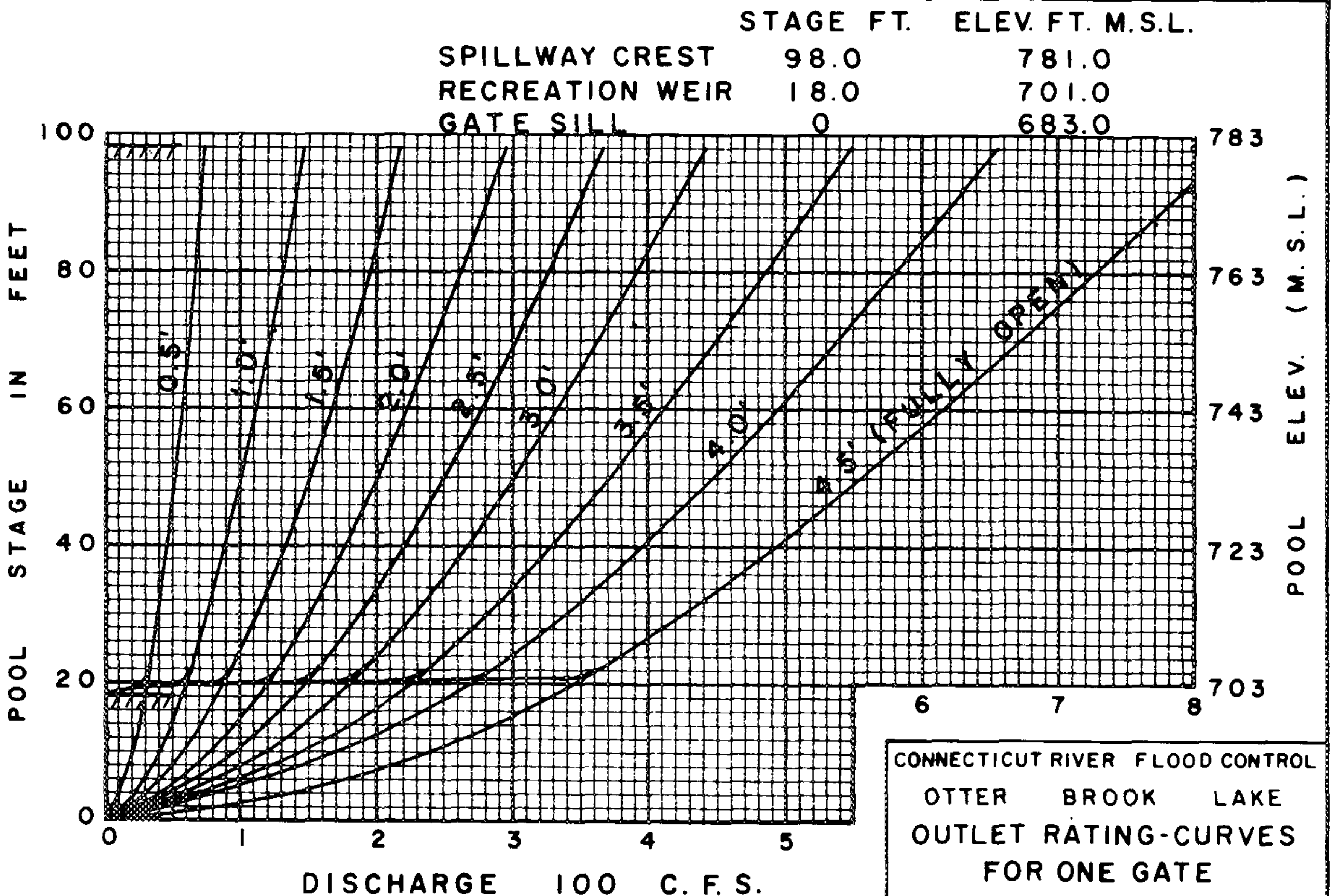
SURRY MOUNTAIN LAKE

OUTLET RATING CURVES
FOR ONE GATE

NEW ENGLAND DIVISION, WALTHAM, MASS.
NOVEMBER 1971



CONNECTICUT RIVER FLOOD CONTROL
SURRY MOUNTAIN LAKE
OUTLET RATING CURVES
FOR TWO GATES FULLY OPEN
NEW ENGLAND DIVISION, WALTHAM, MASS.
NOVEMBER 1971



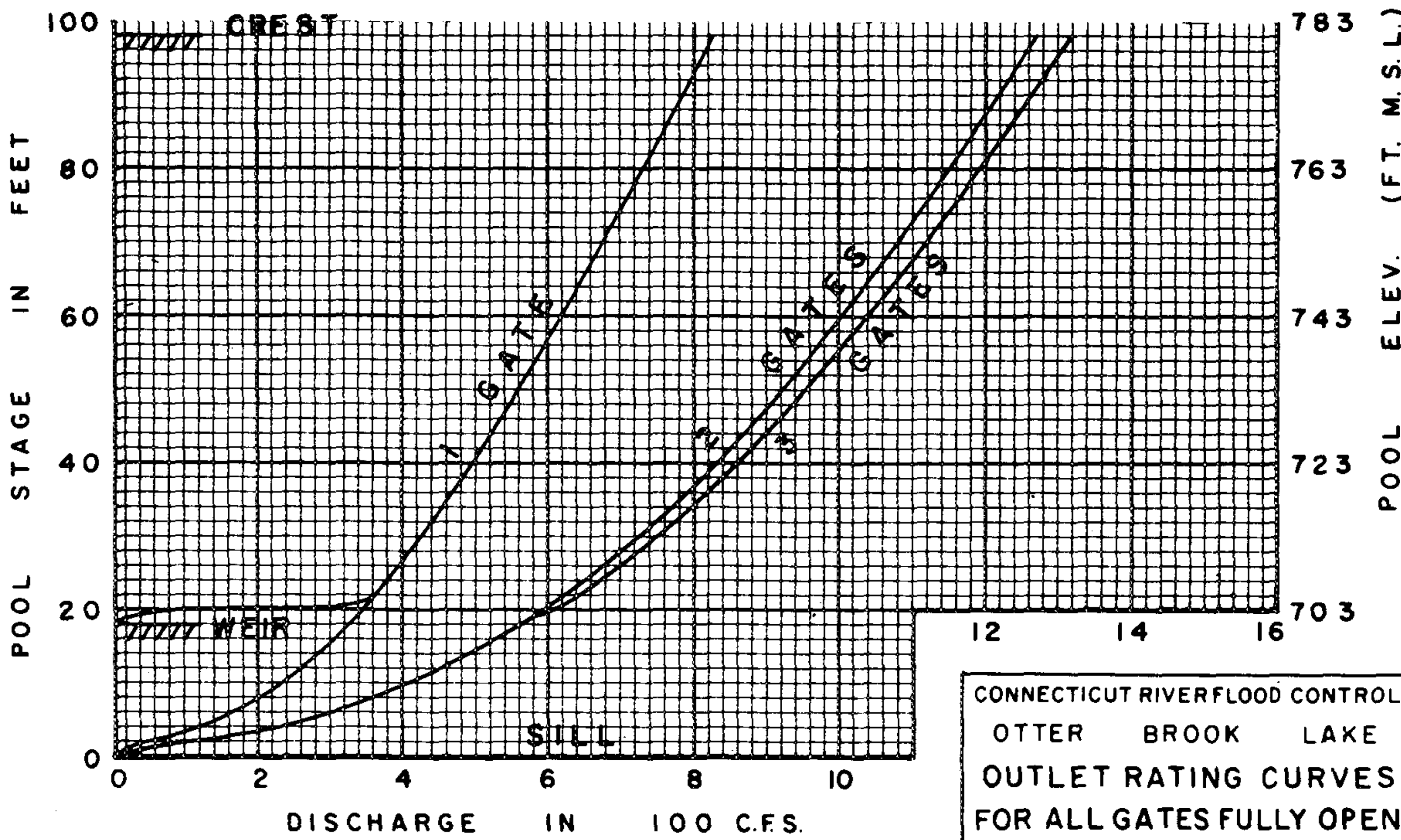
CONNECTICUT RIVER FLOOD CONTROL

OTTER BROOK LAKE

OUTLET RATING-CURVES FOR ONE GATE

NEW ENGLAND DIVISION, WALTHAM, MASS.
NOVEMBER 1971

PLATE E-41



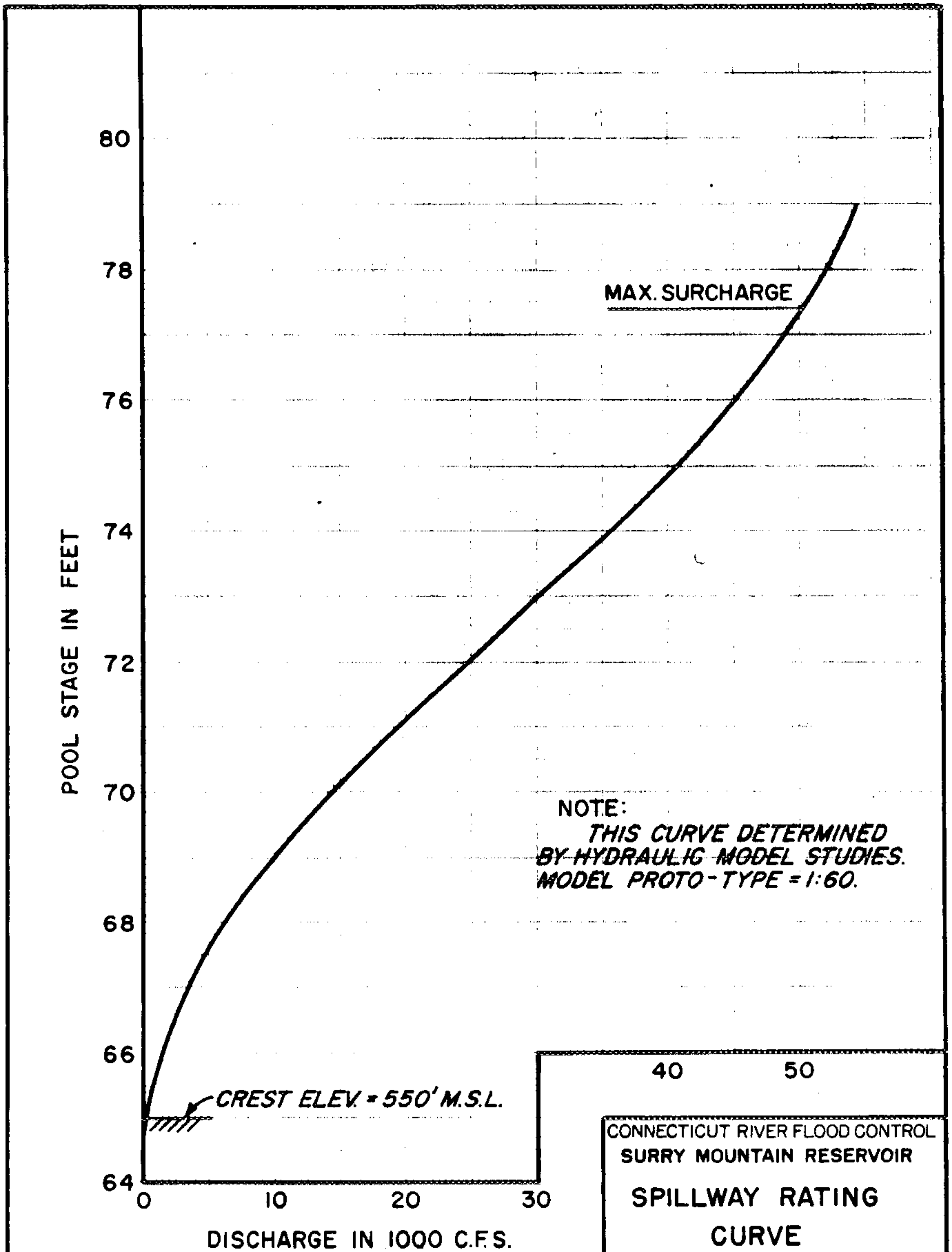
CONNECTICUT RIVER FLOOD CONTROL

OTTER BROOK LAKE

OUTLET RATING CURVES FOR ALL GATES FULLY OPEN

NEW ENGLAND DIVISION, WALTHAM, MASS.

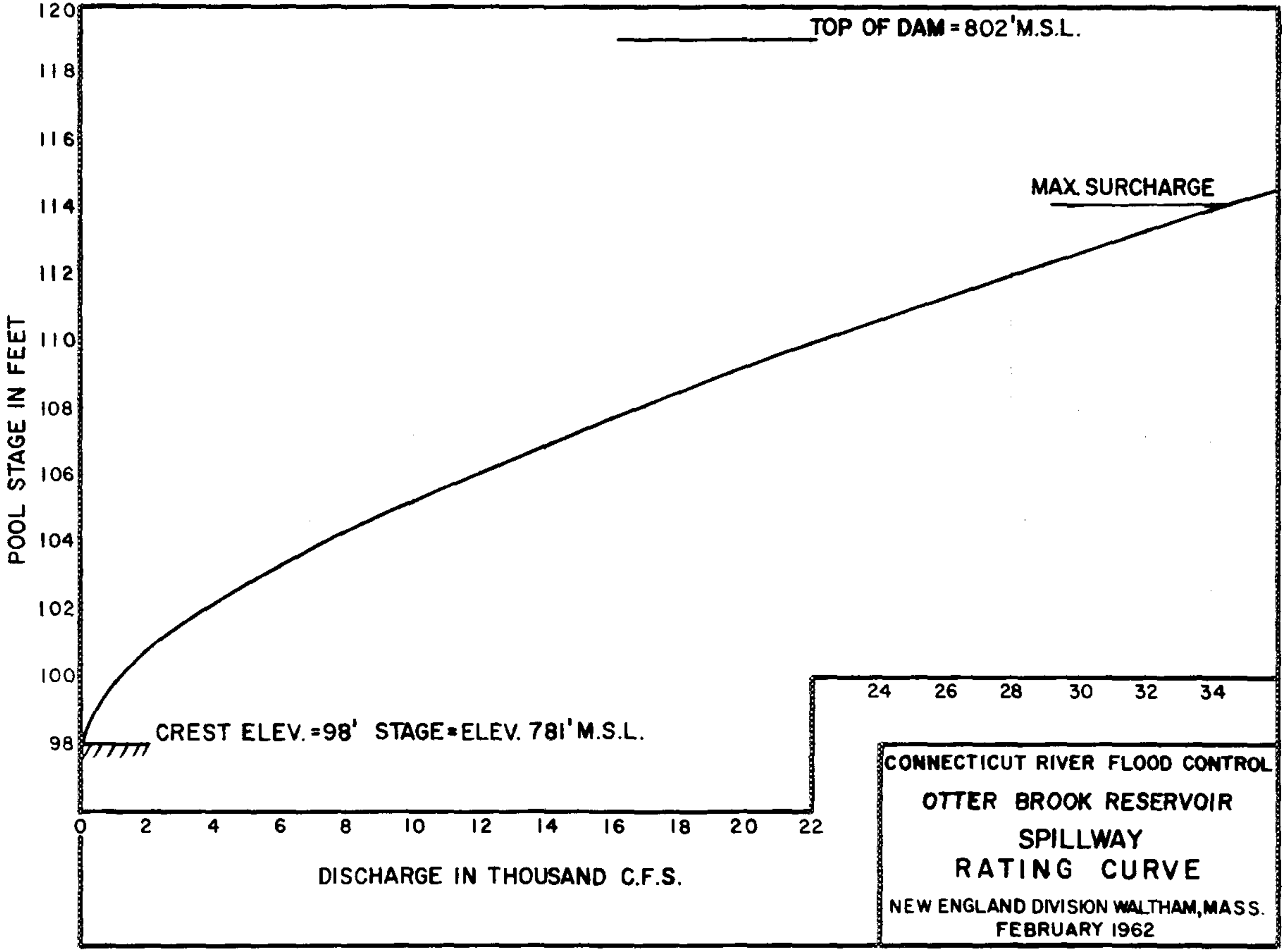
NOVEMBER 1971



CONNECTICUT RIVER FLOOD CONTROL
SURRY MOUNTAIN RESERVOIR

SPILLWAY RATING CURVE

NEW ENGLAND DIVISION, WALTHAM MASS.
FEBRUARY 1962



CONNECTICUT RIVER FLOOD CONTROL

OTTER BROOK RESERVOIR

SPILLWAY

RATING CURVE

NEW ENGLAND DIVISION WALTHAM, MASS.
FEBRUARY 1962

Sta. No. [illegible]

GEOLOGICAL SURVEY (WATER RESOURCES DIVISION)

Table No. 17

Begin 6 7 1 0 0 1 (YR. MO. D. HR.)

Rating table for Ashuelot River below Surry Mountain Lake near Keene, N.H.

from Oct. 1, 1967 *to* ______, *from* ______ *to* ______, *from* ______ *to* ______

Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference
Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs
.00			5.00	33.5	9.5	7.00	491	32	9.00	1096	28	.00			.00			.00		
.10			.10	43	11	.10	523	32	.10	1124	28	.10			.10			.10		
.20			.20	54	12	.20	555	32	.20	1152	28	.20			.20			.20		
.30			.30	66	14	.30	587	32	.30	1180	28	.30			.30			.30		
.40			.40	80	14	.40	619	32	.40			.40			.40			.40		
.50			.50	94	16	.50	651	32	.50			.50			.50			.50		
.60			.60	110	18	.60	683	32	.60			.60			.60			.60		
.70			.70	128	20	.70	715	32	.70			.70			.70			.70		
.80			.80	148	22	.80	747	32	.80			.80			.80			.80		
.90			.90	170	24	.90	779	31	.90			.90			.90			.90		
4.05	0.11		6.00	194	26	8.00	810	30	.00			.00			.00			.00		
.10	.29		.10	220	27	.10	840	30	.10			.10			.10			.10		
.20	.86		.20	247	28	.20	870	29	.20			.20			.20			.20		
.30	1.93		.30	275	29	.30	899	29	.30			.30			.30			.30		
.40	3.75		.40	304	30	.40	928	28	.40			.40			.40			.40		
.50	6.30		.50	334	31	.50	956	28	.50			.50			.50			.50		
.60	9.65	4.25	.60	365	31	.60	984	28	.60			.60			.60			.60		
.70	13.9	5.3	.70	396	31	.70	1012	28	.70			.70			.70			.70		
.80	19.2	6.5	.80	427	32	.80	1040	28	.80			.80			.80			.80		
.90	25.7	7.8	.90	459	32	.90	1068	28	.90			.90			.90			.90		

This table is applicable for open-channel conditions. It is based on 13 discharge measurements made during 1967(257,258) 1968(263-270), 1969(271-273) and is ______ well defined between ______ cfs and ______ cfs.

It is identical with rating 16 below 6.6 ft.

Extended from 9.1 to 9.3 ft. by JDL 6-30-69, checked by DJF

Comp. by JDL date 11-7-68

Ckd. by BAG date 1-20-69

PLATE E-45

GEOLOGICAL SURVEY (WATER RESOURCES DIVISION)

Table No. 10

Rating table for Otter Brook below Otter Brook Dam, near Keene, N.H.

Begin 6 8 1 0 0 1 - - (YR. MO. D. HR.)

from Oct. 1, 1968 *to* ..., *from* ... *to* ..., *from* ... *to* ...

Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference
Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs
.00			5.00			7.00	135	22	.00			.00			.00			.00		
.10			.10			.10	157	23	.10			.10			.10			.10		
.20			.20	0		.20	180	25	.20			.20			.20			.20		
.30			.30	0.12		.30	205	25	.30			.30			.30			.30		
.40			.40	.50		.40	230	30	.40			.40			.40			.40		
.50			.50	1.45		.50	260	30	.50			.50			.50			.50		
.60			.60	2.85		.60	290	30	.60			.60			.60			.60		
.70			.70	4.9	2.8	.70	320	30	.70			.70			.70			.70		
.80			.80	7.7	3.8	.80	350	35	.80			.80			.80			.80		
.90			.90	11.5	4.5	.90	380	35	.90			.90			.90			.90		
.00			.00	16	6	8.00	420	40	.00			.00			.00			.00		
.10			.10	22	6.5	.10	460	40	.10			.10			.10			.10		
.20			.20	28.5	8	.20	500	40	.20			.20			.20			.20		
.30			.30	36.5	10	.30	540	40	.30			.30			.30			.30		
.40			.40	46.5	11.5	.40	580	40	.40			.40			.40			.40		
.50			.50	58	12	.50	620	40	.50			.50			.50			.50		
.60			.60	70	13	.60	660	40	.60			.60			.60			.60		
.70			.70	83	15	.70			.70			.70			.70			.70		
.80			.80	98	17	.80			.80			.80			.80			.80		
.90			.90	115	20	.90			.90			.90			.90			.90		

This table is applicable for open-channel conditions. It is based on 10 discharge measurements made during 1968(107, 108, 110, 111) 1969(113-117), 1970(118) and is ... well defined between ... cfs and ... cfs.

It is identical with rating 9 below 5.9 ft. and above 7.3 ft.

Comp. by JDL date 12-5-69

Ckd. by DJF date 12-9-69

PLATE E-46

9-210
(Rev. 2-67)

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY (WATER RESOURCES DIVISION)

Sta. No. ________

Table No. 56

Begin 6 8 1 0 0 1 (YR. MO. D. HR)

Rating table for Ashuelot River near Gilsum, N.H.

from Oct. 1, 1968 *to* ______, *from* ______ *to* ______, *from* ______ *to* ______

Gage height (Feet)	Discharge (Cfs)	Difference (Cfs)	Gage height (Feet)	Discharge (Cfs)	Difference (Cfs)	Gage height (Feet)	Discharge (Cfs)	Difference (Cfs)	Gage height (Feet)	Discharge (Cfs)	Difference (Cfs)	Gage height (Feet)	Discharge (Cfs)	Difference (Cfs)	Gage height (Feet)	Discharge (Cfs)	Difference (Cfs)
.00			2.00	30	5	4.00	255	21	6.00	800	30	8.00	1530	50	10.00	2730	70
.10			.10	35	5	.10	276	22	.10	830	30	.10	1580	50	.10	2800	
.20			.20	40	6	.20	298	24	.20	860	30	.20	1630	50	.20		
.30			.30	46	6	.30	322	24	.30	890	30	.30	1680	50	.30		
.40			.40	52	7	.40	346	24	.40	920	30	.40	1730	55	.40		
.50			.50	59	8	.50	370	25	.50	950	30	.50	1785	55	.50		
.60			.60	67	9	.60	395	26	.60	980	30	.60	1840	60	.60		
.70			.70	76	9	.70	421	27	.70	1010	30	.70	1900	60	.70		
.80			.80	85	10	.80	448	28	.80	1040	30	.80	1960	60	.80		
.90			.90	95	11	.90	476	28	.90	1070	30	.90	2020	60	.90		
1.00	4.1	1.3	.00	106	11	5.00	504	28	7.00	1100	30	9.00	2080	60	.00		
.10	5.4	1.4	.10	117	12	.10	532	29	.10	1130	40	.10	2140	60	.10		
.20	6.8	1.7	.20	129	13	.20	561	29	.20	1170	40	.20	2200	65	.20		
.30	8.5	2.0	.30	142	14	.30	590	30	.30	1210	40	.30	2265	65	.30		
.40	10.5	2.3	.40	156	14	.40	620	30	.40	1250	40	.40	2330	65	.40		
.50	12.8	2.7	.50	170	15	.50	650	30	.50	1290	40	.50	2395	65	.50		
.60	15.5	3	.60	185	16	.60	680	30	.60	1330	50	.60	2460	65	.60		
.70	18.5	3.5	.70	201	17	.70	710	30	.70	1380	50	.70	2525	65	.70		
.80	22	3.8	.80	218	18	.80	740	30	.80	1430	50	.80	2590	70	.80		
.90	25.8	4.2	.90	236	19	.90	770	30	.90	1480	50	.90	2660	70	.90		

This table is applicable for open-channel conditions. It is based on 13 discharge measurements made during 1964(432), 1965(443), 1966(455), 1967(466), 1968(474,477,478), 1969(479,480,482-484), and is ______ well defined between ______ cfs and ______ cfs. 1970(485), and is identical with rating 55 from 4.2 to 4.6 ft. and above 7.1 ft.

Comp. by BAG date 1-22-70
Ckd. by JDL date 1-30-70

U.S. GOVERNMENT PR

PLATE E-47

GEOLOGICAL SURVEY (WATER RESOURCES DIVISION)

Table No. 4 9

Rating table for South Branch Ashuelot River at Webb, near Marlborough, N.H.

Begin 6 8 0 3 1 9 (YR. MO. D. HR.)

from March 19, 1968 *to* , *from* *to* , *from* *to*

Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference
Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs
1.00			3.00	41.5	3.5	5.00	570	65	7.00	330	250	.00			.00			.00		
.10			.10	45	4	.10	635	70	.10	3550	250	.10			.10			.10		
.28	0		.20	49	4	.20	705	75	.20	3800	250	.20			.20			.20		
.30	.05		.30	53	4.5	.30	780	80	.30	4050	300	.30			.30			.30		
.40	.45		.40	57.5	5.5	.40	860	90	.40	4350	300	.40			.40			.40		
.50	1.1	1.25	.50	63	6	.50	950	100	.50	4650	300	.50			.50			.50		
.60	2.35	1.65	.60	69	8	.60	1050	100	.60	4950	350	.60			.60			.60		
.70	4.0	1.9	.70	77	10	.70	1150	110	.70	5300	350	.70			.70			.70		
.80	5.9	2.1	.80	87	13	.80	1260	120	.80	5650	350	.80			.80			.80		
.90	8.0	2.3	.90	100	18	.90	1380	130	.90	6000		.90			.90			.90		
2.00	10.3	2.4	4.00	118	25	6.00	1510	130	8.00			.00			.00			.00		
.10	12.7	2.5	.10	143	32	.10	1640	140	.10			.10			.10			.10		
.20	15.2	2.8	.20	175	38	.20	1780	150	.20			.20			.20			.20		
.30	18.0	3.1	.30	213	44	.30	1930	160	.30			.30			.30			.30		
.40	21.1	3.2	.40	257	48	.40	2090	180	.40			.40			.40			.40		
.50	24.3	3.3	.50	305	50	.50	2270	180	.50			.50			.50			.50		
.60	27.6	3.4	.60	355	50	.60	2450	200	.60			.60			.60			.60		
.70	31	3.5	.70	405	50	.70	2650	200	.70			.70			.70			.70		
.80	34.5	3.5	.80	455	55	.80	2850	200	.80			.80			.80			.80		
.90	38	3.5	.90	510	60	.90	3050	250	.90			.90			.90			.90		

This table is applicable for open-channel conditions. It is based on 7 discharge measurements made during 1968(421-424), 1969(425-427) and is well defined between cfs and cfs.

It is identical with rating 48 below 1.5 ft. and above 2.3 ft.

Comp. by RAG date 4-29-69

Ckd. by GAL date 6-23-69

U.S. GOVT

PLATE E-48

(Rev. 2-67)

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY (WATER RESOURCES DIVISION)

Sta. No. ________
Table No. 31
Begin 6 8 1 0 0 1 __ (YR. MO. D. HR.)

Rating table for Ashuelot River at Hinsdale, N.H.

from Oct. 1, 1968 *to* ________, *from* ________ *to* ________, *from* ________ *to* ________

Gage height (Feet)	Discharge (Cfs)	Difference (Cfs)	Gage height (Feet)	Discharge (Cfs)	Difference (Cfs)	Gage height (Feet)	Discharge (Cfs)	Difference (Cfs)	Gage height (Feet)	Discharge (Cfs)	Difference (Cfs)	Gage height (Feet)	Discharge (Cfs)	Difference (Cfs)	Gage height (Feet)	Discharge (Cfs)	Difference (Cfs)	Gage height (Feet)	Discharge (Cfs)	Difference (Cfs)
2.00			4.00	362	68	6.00	2280	140	8.00	6300	260	.00			.00			.00		
.10			.10	430	70	.10	2420	150	.10	6560	280	.10			.10			.10		
.20			.20	520	70	.20	2570	160	.20	6840	280	.20			.20			.20		
.30			.30	590	70	.30	2730	160	.30	7120	280	.30			.30			.30		
.40			.40	660	70	.40	2890	170	.40	7400	300	.40			.40			.40		
.50			.50	730	80	.50	3060	180	.50	7700	300	.50			.50			.50		
.60			.60	810	80	.60	3240	180	.60	8000	300	.60			.60			.60		
.70	31	10	.70	890	90	.70	3420	190	.70	8300	300	.70			.70			.70		
.80	41	11	.80	980	90	.80	3610	190	.80	8600	300	.80			.80			.80		
.90	52	13	.90	1070	90	.90	3800	200	.90	8900		.90			.90			.90		
3.00	65	16	5.00	1160	90	7.00	4000	200	.00			.00			.00			.00		
.10	81	18	.10	1250	90	.10	4200	200	.10			.10			.10			.10		
.20	99	21	.20	1340	100	.20	4400	220	.20			.20			.20			.20		
.30	120	24	.30	1440	100	.30	4620	220	.30			.30			.30			.30		
.40	144	27	.40	1540	110	.40	4840	220	.40			.40			.40			.40		
.50	171	30	.50	1650	110	.50	5060	240	.50			.50			.50			.50		
.60	201	33	.60	1760	120	.60	5300	240	.60			.60			.60			.60		
.70	234	36	.70	1880	130	.70	5540	240	.70			.70			.70			.70		
.80	270	41	.80	2010	130	.80	5780	260	.80			.80			.80			.80		
.90	311	51	.90	2140	140	.90	6040	260	.90			.90			.90			.90		

This table is applicable for open-channel conditions. It is based on 12 discharge measurements made during 1964(421,422), 1968(460,461), 1969(464-470), 1970(471) and is ________ well defined between ________ cfs and ________ cfs.

Comp. by RAG date 1-29-70

It is identical with rating 30 below 5.6 ft.

Ckd. by JDL date 4-13-70

U.S. GOVERNMENT

PLATE E-49

9-210
(Rev. 2-67)

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY (WATER RESOURCES DIVISION)

Sta. No. 01 70500
Table No. 20
Begin 66 1 001 __ (YR. MO. D. HR.)

Rating table for Connecticut River at Montague City, Mass.

from October 1, 1966, *from* ______ *to* ______, *from* ______ *to* ______

Gage height	Discharge	Differ-ence	Gage height	Discharge	Differ-ence	Gage height	Discharge	Differ-ence	Gage height	Discharge	Differ-ence	Gage height	Discharge	Differ-ence	Gage height	Discharge	Differ-ence	Gage height	Discharge	Differ-ence
Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs
17.00	30600	360	19.00	39000	380	21.00	46800	400	23.00	55000	440	25.00	64000	480	27.00	73800	520	29.00	84200	540
.10	30960	360	.10	39380	380	.10	47200	400	.10	55440	440	.10	64480	480	.10	74320	520	.10	84740	540
.20	31320	360	.20	39760	380	.20	47600	400	.20	55880	440	.20	64960	480	.20	74840	520	.20	85280	540
.30	31680	360	.30	40140	380	.30	48000	400	.30	56320	440	.30	65440	480	.30	75360	520	.30	85820	540
.40	32040	360	.40	40520	380	.40	48400	400	.40	56760	440	.40	65920	480	.40	75880	520	.40	86360	540
.50	32400	360	.50	40900	380	.50	48800	400	.50	57200	440	.50	66400	480	.50	76400	520	.50	86900	540
.60	32760	360	.60	41280	380	.60	49200	400	.60	57640	440	.60	66880	480	.60	76920	520	.60	87440	540
.70	33120	360	.70	41660	380	.70	49600	400	.70	58080	440	.70	67360	480	.70	77440	520	.70	87980	540
.80	33480	360	.80	42040	380	.80	50000	400	.80	58520	440	.80	67840	480	.80	77960	520	.80	88520	540
.90	33840	360	.90	42420	380	.90	50400	400	.90	59660	440	.90	68320	480	.90	78480	520	.90	89060	540
18.00	35200	380	20.00	42800	400	22.00	50800	420	24.00	59400	460	26.00	68800	500	28.00	7900	520	30.00	89600	540
.10	35580	380	.10	43200	400	.10	51220	420	.10	59860	460	.10	69300	500	.10	79520	520	.10	90140	540
.20	35960	380	.20	43600	400	.20	51640	420	.20	60320	460	.20	69800	500	.20	80040	520	.20	90680	540
.30	36340	380	.30	44000	400	.30	52060	420	.30	60780	460	.30	70300	500	.30	80560	520	.30	91220	540
.40	36720	380	.40	44400	400	.40	52480	420	.40	61240	460	.40	70800	500	.40	81080	520	.40	91760	540
.50	37100	380	.50	44800	400	.50	52900	420	.50	61700	460	.50	71300	500	.50	81600	520	.50	92300	540
.60	37480	380	.60	45200	400	.60	53320	420	.60	62160	460	.60	71800	500	.60	82120	520	.60	92840	540
.70	37860	380	.70	45600	400	.70	53740	420	.70	62620	460	.70	72300	500	.70	82640	520	.70	93380	540
.80	38240	380	.80	46000	400	.80	54160	420	.80	63080	460	.80	72800	500	.80	83160	520	.80	93920	540
.90	38620	380	.90	46400	400	.90	54580	420	.90	63540	460	.90	73300	500	.90	83680	520	.90	94460	540

This table is applicable for open-channel conditions. It is based on ______ discharge measurements made during ______
It is identical with rating 19 above and is ______ well defined between 5,000 cfs and 150,000 cfs.
6.0 feet

Comp. by RAG date 12-8-70
Ckd. by JWB date 12-17-70

U.S. GOVERNMENT PLATE E-49 A

9-210
(Rev. 2-67)

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY (WATER RESOURCES DIVISION)

Sta. No. 0 1 1 _ 6 5 0 0
Table No. 2 0
Begin 3 5 1 0 0 1 (YR. MO. D. HR.)

Rating table for Connecticut River at Montague City, Mass.
from October 1, 1935 *to* ...., *from* .... *to* ...., *from* .... *to* ....

Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference
Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs
31.00	95000	550	33.00	106500	650	35.00	120000	700	37.00	134000	700	39.00	149000	800	41.00	165000	800	43.00	181000	800
.10	95550	550	.10	107150	650	.10	120700	700	.10	134700	700	.10	149800	800	.10	165800	800	.10	181800	800
.20	96100	550	.20	107800	650	.20	121400	700	.20	135400	700	.20	150600	800	.20	166600	800	.20	182600	800
.30	96650	550	.30	108450	650	.30	122100	700	.30	136100	700	.30	151400	800	.30	167400	800	.30	183400	800
.40	97200	550	.40	109100	650	.40	122800	700	.40	136800	700	.40	152200	800	.40	168200	800	.40	184200	800
.50	97750	550	.50	109750	650	.50	123500	700	.50	137500	700	.50	153000	800	.50	169000	800	.50	185000	800
.60	98300	550	.60	110400	650	.60	124200	700	.60	138200	700	.60	153800	800	.60	169800	800	.60	185800	800
.70	98850	550	.70	111050	650	.70	124900	700	.70	138900	700	.70	154600	800	.70	170600	800	.70	186600	800
.80	99400	550	.80	111700	650	.80	125600	700	.80	139600	700	.80	155400	800	.80	171400	800	.80	187400	800
.90	99950	550	.90	112350	650	.90	126300	700	.90	140300	700	.90	156200	800	.90	172200	800	.90	188200	800
32.00	100500	600	34.00	113000	700	36.00	127000	700	38.00	141000	800	40.00	157000	800	42.00	173000	800	44.00	189000	800
.10	101100	600	.10	113700	700	.10	127700	700	.10	141800	800	.10	157800	800	.10	173800	800	.10	189800	800
.20	101700	600	.20	114400	700	.20	128400	700	.20	142600	800	.20	158600	800	.20	174600	800	.20	190600	800
.30	102300	600	.30	115100	700	.30	129100	700	.30	143400	800	.30	159400	800	.30	175400	800	.30	191400	800
.40	102900	600	.40	11580	700	.40	129800	700	.40	144200	800	.40	160200	800	.40	176200	800	.40	192200	800
.50	103500	600	.50	116500	700	.50	130500	700	.50	145000	800	.50	161000	800	.50	177000	800	.50	193000	800
.60	104100	600	.60	117200	700	.60	131200	700	.60	145800	800	.60	161800	800	.60	177800	800	.60	193800	800
.70	104700	600	.70	117900	700	.70	131900	700	.70	146600	800	.70	162600	800	.70	178600	800	.70	194600	800
.80	105300	600	.80	118600	700	.80	132600	700	.80	147400	800	.80	163400	800	.80	179400	800	.80	195400	800
.90	105900	600	.90	119300	700	.90	133300	700	.90	148200	800	.90	164200	800	.90	180200	800	.90	196200	800

This table is applicable for open-channel conditions. It is based on ______ discharge measurements made during ....
It is identical with rating 19 above and is .... well defined between 5,000 cfs and 150,000 cfs.
6.0 feet.

Comp. by RAG date 12-8-70
Ckd. by JWB date 12-17-70

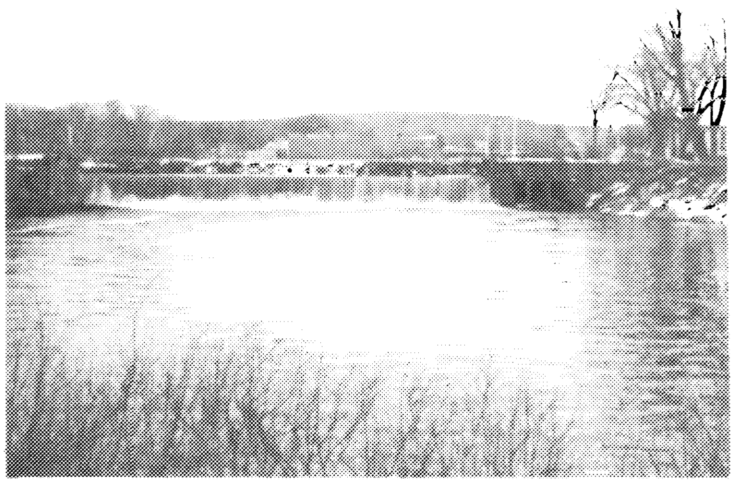
U.S. GOVERNMENT PLATE E-49B

VIEW OF SURRY MOUNTAIN LAKE
(APRIL 1969 FLOOD MAXIMUM STAGE 55.5)

VIEW OF OTTER BROOK LAKE
(APRIL 1969 FLOOD MAXIMUM STAGE 82.6)

VILLAGE POND
MARLOW, N.H.

TYPE - CONCRETE AND ROCK
LENGTH DAM - 140' ±
HEIGHT DAM - 8' ±
SPILLWAY LENGTH - 100' ±
FLASHBOARDS - 70' x 10" ±
DRAINAGE AREA - 37.5 SQ. MI.



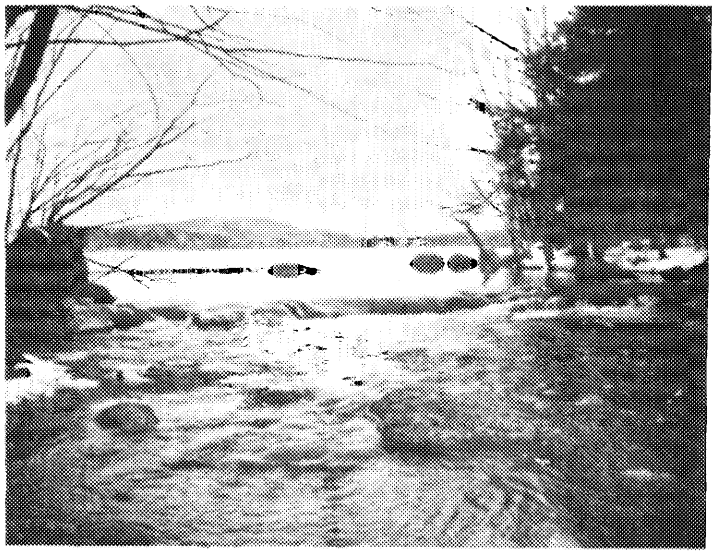
FAULKNER AND COLONY
DAM
KEENE, N.H.

TYPE - CONCRETE AND ROCK
LENGTH DAM - 175' ±
HEIGHT DAM - 7' ±
SPILLWAY LENGTH - 135' ±
FLASHBOARDS - 135' x 1' ±
GATES - 3 (6' x 5') ±
DRAINAGE AREA - 112.2 SQ. MI.

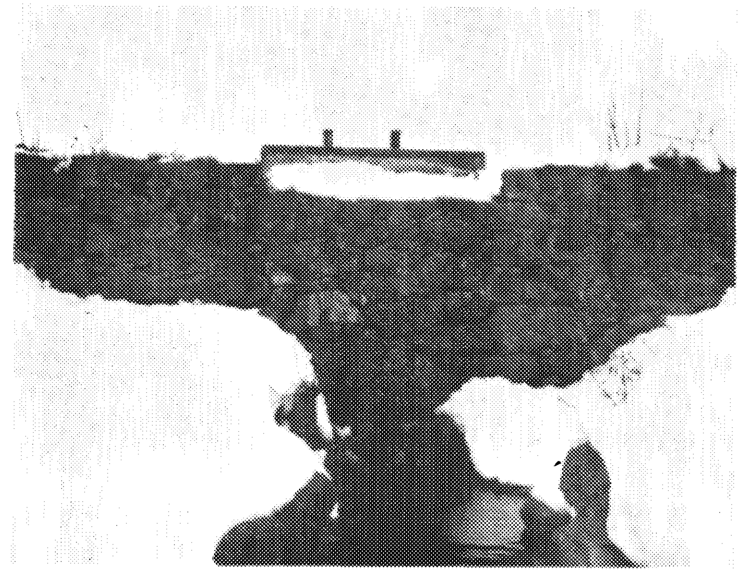
HOMESTEAD WOOLEN
MILL DAM
WEST SWANZEY, N.H.

TYPE - WOODEN CRIB
LENGTH DAM - 168'
HEIGHT DAM - 8' ±
SPILLWAY LENGTH - 168'
FLASHBOARDS - NONE
DRAINAGE AREA - 312 SQ. MI.

ASHUELOT POND
WASHINSTON, N.H.



ROCK SPILLWAY LOOKING UPSTREAM

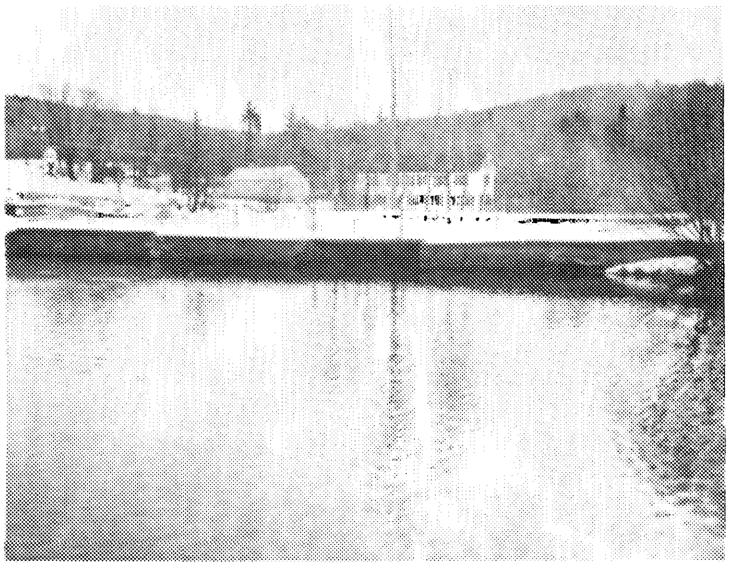


OUTLETWORKS LOOKING UPSTREAM

TYPE OF DAM – EARTH AND ROCK
LENGTH DAM – 150'±
HEIGHT DAM – 15'±
SPILLWAY LENGTH – 25'±
NUMBER OF GATES – 2
DRAINAGE AREA – 26.9 SQ. MI.

GRANITE LAKE

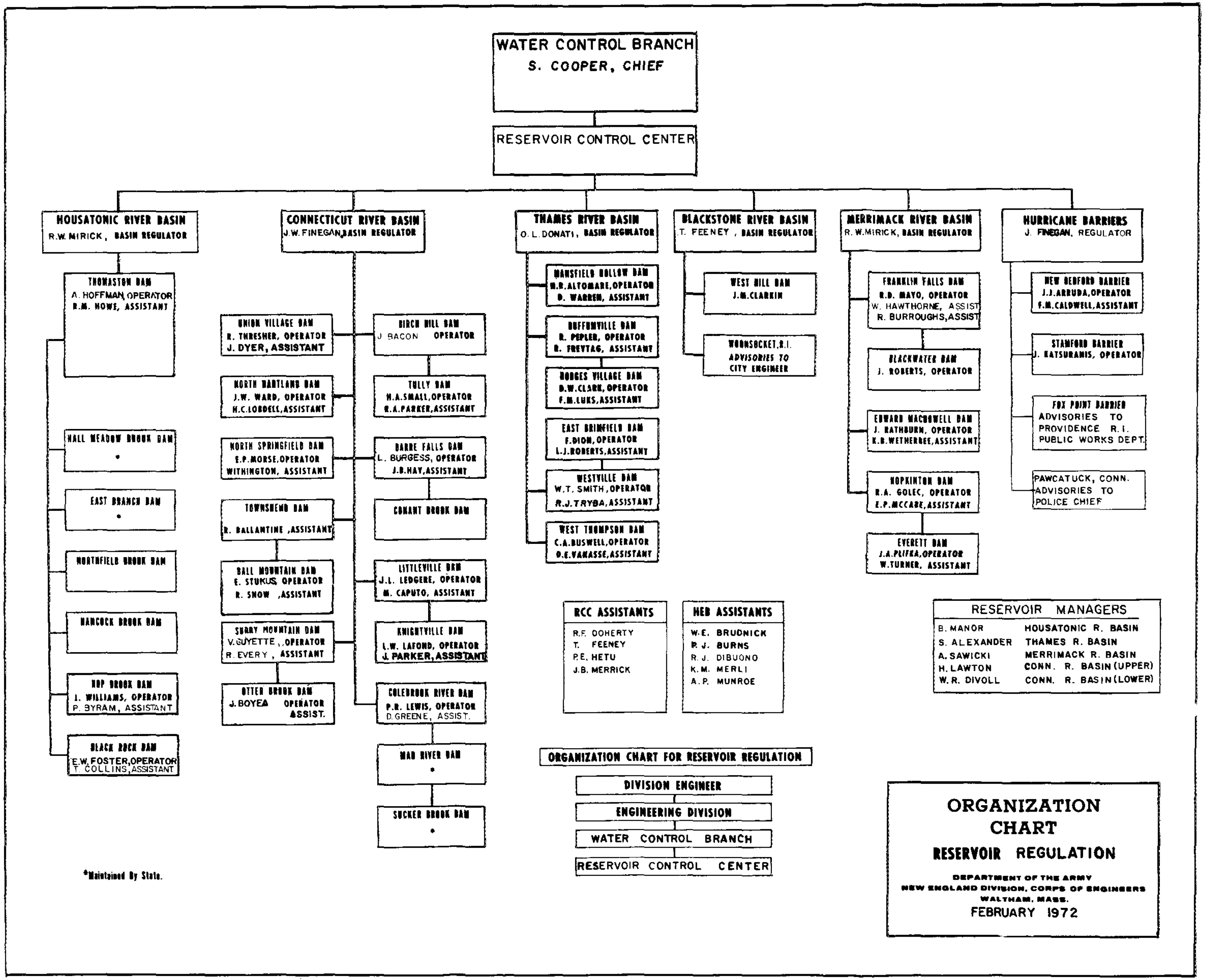
NELSON, N. H.



DAM LOOKING DOWNSTREAM

FLASHBOARD SPILLWAY LOOKING UPSTREAM

TYPE OF DAM – CONCRETE AND ROCK
LENGTH DAM – 50' ±
HEIGHT DAM – 8' ±
SPILLWAY LENGTH – 15' ±
GATE – 12" x 16" ±
DRAINAGE AREA – 4.2 SQ. MI.



WATER CONTROL BRANCH
S. COOPER, CHIEF
RESERVOIR CONTROL CENTER
HOUSATONIC RIVER BASIN
R.W. MIRICK, BASIN REGULATOR
THOMASTON DAM
A. HOFFMAN, OPERATOR
R.M. HOWE, ASSISTANT
HALL MEADOW BROOK DAM
*
EAST BRANCH DAM
*
NORTHFIELD BROOK DAM
HANCOCK BROOK DAM
HOP BROOK DAM
I. WILLIAMS, OPERATOR
P. BYRAM, ASSISTANT
BLACK ROCK DAM
E.W. FOSTER, OPERATOR
T. COLLINS, ASSISTANT
CONNECTICUT RIVER BASIN
J.W. FINEGAN, BASIN REGULATOR
UNION VILLAGE DAM
R. THRESHER, OPERATOR
J. DYER, ASSISTANT
NORTH HARTLAND DAM
J.W. WARD, OPERATOR
H.C. LOBDELL, ASSISTANT
NORTH SPRINGFIELD DAM
E.P. MORSE, OPERATOR
WITHINGTON, ASSISTANT
TOWNSHEND DAM
R. BALLANTINE, ASSISTANT
BALL MOUNTAIN DAM
E. STUKUS OPERATOR
R. SNOW, ASSISTANT
SURRY MOUNTAIN DAM
V. GUYETTE, OPERATOR
R. EVERY, ASSISTANT
OTTER BROOK DAM
J. BOYEA OPERATOR
ASSIST.
BIRCH HILL DAM
J. BACON OPERATOR
TULLY DAM
H.A. SMALL, OPERATOR
R.A. PARKER, ASSISTANT
BARRE FALLS DAM
L. BURGESS, OPERATOR
J.B. HAY, ASSISTANT
CONANT BROOK DAM
LITTLEVILLE DAM
J.L. LEDGERE, OPERATOR
M. CAPUTO, ASSISTANT
KNIGHTVILLE DAM
L.W. LAFOND, OPERATOR
J. PARKER, ASSISTANT
COLEBROOK RIVER DAM
P.R. LEWIS, OPERATOR
D. GREENE, ASSIST.
MAD RIVER DAM
*
SUCKER BROOK DAM
*
THAMES RIVER BASIN
O.L. DONATI, BASIN REGULATOR
MANSFIELD HOLLOW DAM
W.R. ALTOMARE, OPERATOR
D. WARREN, ASSISTANT
BUFFUMVILLE DAM
R. PEPLER, OPERATOR
R. FREYTAG, ASSISTANT
HODGES VILLAGE DAM
D.W. CLARK, OPERATOR
F.M. LUKS, ASSISTANT
EAST BRIMFIELD DAM
F. DION, OPERATOR
L.J. ROBERTS, ASSISTANT
WESTVILLE DAM
W.T. SMITH, OPERATOR
R.J. TRYBA, ASSISTANT
WEST THOMPSON DAM
C.A. BUSWELL, OPERATOR
O.E. VANASSE, ASSISTANT
BLACKSTONE RIVER BASIN
T. FEENEY, BASIN REGULATOR
WEST HILL DAM
J.M. CLARKIN
WOONSOCKET, R.I.
ADVISORIES TO
CITY ENGINEER
MERRIMACK RIVER BASIN
R. W. MIRICK, BASIN REGULATOR
FRANKLIN FALLS DAM
R.D. MAYO, OPERATOR
W. HAWTHORNE, ASSIST
R. BURROUGHS, ASSIST
BLACKWATER DAM
J. ROBERTS, OPERATOR
EDWARD MACDOWELL DAM
J. RATHBURN, OPERATOR
K.B. WETHERBEE, ASSISTANT
HOPKINTON DAM
R.A. GOLEC, OPERATOR
E.P. MCCABE, ASSISTANT
EVERETT DAM
J.A. PLIFKA, OPERATOR
W. TURNER, ASSISTANT
HURRICANE BARRIERS
J. FINEGAN, REGULATOR
NEW BEDFORD BARRIER
J.J. ARRUDA, OPERATOR
F.M. CALDWELL, ASSISTANT
STAMFORD BARRIER
J. KATSURANIS, OPERATOR
FOX POINT BARRIER
ADVISORIES TO
PROVIDENCE R.I.
PUBLIC WORKS DEPT.
PAWCATUCK, CONN.
ADVISORIES TO
POLICE CHIEF
RCC ASSISTANTS
R.F. DOHERTY
T. FEENEY
P.E. HETU
J.B. MERRICK
HEB ASSISTANTS
W.E. BRUDNICK
R.J. BURNS
R.J. DIBUONO
K.M. MERLI
A.P. MUNROE
RESERVOIR MANAGERS
B. MANOR HOUSATONIC R. BASIN
S. ALEXANDER THAMES R. BASIN
A. SAWICKI MERRIMACK R. BASIN
H. LAWTON CONN. R. BASIN (UPPER)
W.R. DIVOLL CONN. R. BASIN (LOWER)
ORGANIZATION CHART FOR RESERVOIR REGULATION
DIVISION ENGINEER
ENGINEERING DIVISION
WATER CONTROL BRANCH
RESERVOIR CONTROL CENTER
*Maintained By State.
ORGANIZATION CHART
RESERVOIR REGULATION
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.
FEBRUARY 1972

PLATE E-55